Municipal Water Use Efficiency Guideline Jaipur

Water Analysis, Innovations, and Systems Program

February 2013

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Cover photo: Peri-urban household in Jaipur. Photograph by Walter Weaver.

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ABBREVIATIONS AND ACRONYMS

AIILSG	All India Institute of Local Self Government
BMP	Best Management Practices (for water conservation)
CPHEEO	Central Public Health Engineering and Environment Organization
CUWCC	California Urban Water Conservation Council
CGWA	Central Ground Water Board
CII	Confederation of Indian Industries
DAI	Development Alternatives, Inc.
ECBC	Energy Conservation Building Code
GoI	Government of India
GoR	Government of Rajasthan
gpf	Gallons per flush
gpm	Gallons per minute
GRIHA	Green Rating for Integrated Habitat Assessment
GWD	Groundwater Department
HIG	High income group
IGBC	Indian Green Building Council
IEC	Information, education and communication
IPCC	Intergovernmental Panel on Climate Change
JDA	Jaipur Development Authority
JMC	Jaipur Municipal Corporation, referred to as Jaipur Nagar Nigam (JNN)
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
LEED	Leadership in Energy and Environmental Design
L/d	Liters per day
Lpcd	Liters per capita per day
LIG	Low income group
MIG	Middle income group
ML	Million liters
MLD	Million liters per day
NAPCC	National Action Plan on Climate Change
NWM	National Water Mission
NRW	Non-revenue water
NOC	Notified Areas for Control and Regulation of Groundwater
PHED	Public Health Engineering Department
PPM	Parts per million
RWH	Rainwater harvesting
RIICO	Rajasthan Industrial Development and Investment Corporation
RSEP	Rajasthan State Environmental Policy
RSPCB	Rajasthan State Pollution Control Board
SAPCC	State Action Plan on Climate Change
SEIAA	State Environmental Impact Assessment Authority
SLB	Service Level Benchmark
STP	Sewage (Wastewater) Treatment Plant, also known as water pollution control plant (WPCP)
SEZ	Special Economic Zone
SWP	State Water Policy
TMCM	Thousand million cubic meters
UV	Ultraviolet
USAID	United States Agency for International Development
UDH	Urban Development and Housing
WAISP	Water Analysis, Innovations, and Systems Program
WC	Water Closet (also, Bathroom, Restroom, Toilet)
WF	Water Factor (Unit of water use by dishwasher or washing machine per cycle per unit load)

EXECUTIVE SUMMARY

The Water Analysis, Innovations, and Systems Program (WAISP) is a USAID-supported initiative to increase the security of potable water supply and sanitation services by building resiliency to global climate change and advancing sustainable approaches to water management. The program includes two components: (1) assessment of the water sector in India in the context of climate change, food security, and health, which was completed in June 2011, and (2) analysis of the potential and feasibility of inter-sectoral water use, primarily providing municipal wastewater for use by industry or industrial clusters in three cities—Faridabad, Jaipur, and Pune. This has been implemented by Development Alternatives, Inc. (DAI), with support from The Communities Group International, and the All India Institute of Local Self Government (AIILSG). In addition, the Confederation of Indian Industry's (CII) Triveni Water Institute is working in parallel with USAID to conduct water audits and carry the initiative forward.

The second component has included several elements, and this report consolidates all of the activities and analysis completed related to Jaipur:

1. Review of the water supply and sanitation infrastructure serving the city, as well as a desk analysis of the potential climate change impacts on Jaipur and the threats they pose to water resources in the short and long term.
2. Analysis of the legal framework related to water resources.
3. Summary presentation of primary survey research of the principal non-industrial water users in the city, totaling 502 sampling units.
4. Presentation of opportunities and recommendations to improve urban water use efficiency, including specific projects for consideration by officials and water users in Jaipur.
5. Compendium of selected national and international best practice case studies and references to engage stakeholders in considering the merits of various successful models.

Water scarcity is a looming threat to orderly development and growth of India's major cities, in similar fashion to most of the semi-arid and arid regions of the world. A fast growing population and increasing standards of living will combine with the effects of global climate change to exacerbate this scarcity.

National and Local Context

Water scarcity is a looming threat to orderly development and growth of India's major cities, in similar fashion to most of the semi-arid and arid regions of the world. A fast growing population and improving standard of living will combine with the effects of global climate change to exacerbate this scarcity. Fortunately, much can be accomplished to increase the efficiency of water use in India's cities in a relatively short period of time. The reason for this optimism is twofold: (a) current water use efficiency is at a very low level, and (b) international experience and advanced technology can offer proven solutions to maximize the benefits of available water supplies in the most equitable manner possible.

The Twelfth Five Year Plan (2012-2017) released by the Planning Commission, Government of India (GoI) has analyzed in detail the water situation in general and in the specific context of industries. The Plan document quotes estimates of the "2030 Water Resources Group" which indicates that if current patterns continue, about half of the water demand will be unmet by 2030, and therefore recommends a reform agenda and paradigm shift to address the challenge. This shift includes "definite targets for recycling and reuse of water by Indian industry to move in conformity with international standards" (GoI, 2012c). Given this backdrop, WAISP conducted a series of consultative meetings with USAID, CII's Triveni Water Institute, and officials within various municipalities. The guiding principles for selecting Faridabad, Jaipur, and Pune were: (1) water scarcity with high potential for growth; (2) feasible within a one year time frame; (3) enables donors and municipalities to follow-up with longer-term initiatives based on the results; (4) interest of municipal authorities to focus on the interface across the urban built environment and industry; (5) linkages with CII's networks for follow-up.

For its part, Jaipur depends on both surface and groundwater to meet its municipal water supply needs. The Bisalpur Dam, commissioned in 2010, has become the principal water source; while a chain of deep tubewells importantly supplement the supply.

For its part, Jaipur depends on both surface and groundwater to meet its municipal water supply needs. The Bisalpur Dam, commissioned in 2010, has become the principal water source, while a chain of deep tube wells importantly supplement the supply. Consistent overexploitation of groundwater over many years has resulted in an alarming depletion of the water table, which cannot be replenished by the average annual rainfall of 650mm.

The impacts of climate change on water resources, and vulnerability of the city to these changes has been reviewed from secondary data sources considering the A1B scenario of emissions as defined by the Inter-governmental Panel on Climate Change. WAISP assessed vulnerabilities related to three key potential impacts-reduced groundwater recharge, occurrence of drought, and occurrence of water logging and floods. Findings suggest that vulnerability due to reduced recharge is "medium" in the short term, but significant in the longer term (2050s). The response plan of the city to these threats, particularly to restrict further depletion of groundwater, is commendable. However, there is a strong need to reinforce water stewardship by increasing wastewater reuse, reducing wastage and losses, and promoting water use optimization.

Water Use

A primary quantitative survey was designed to supplement the secondary data and qualitative information collected. The survey assessed the pattern of water use within the city area across different segments of water users, including domestic and commercial (but not industrial). While it had a limited scope, the survey yielded valuable reinforcing information that, when taken in concert with other data sources, studies, and priorities, suggest trends which may be helpful for decision-makers interested in identifying opportunities for water use optimization.

The focus of the survey was on domestic water use, covering 302 households from residential clusters representing different areas of the city. This included areas of the Walled City, neighborhoods developed in the last 30-40 years, low-income and unauthorized settlements near Jawharnagar, as well as very recent developments on the southern fringe of the city near Sitapur industrial area. Most of the households depend entirely on municipal water supply (89%), although 12% of the middle income group and 16% of the high income group reported having their own water sources. Notably, very few respondents, just 9%, have dual flush toilets,[1] which present an important opportunity for conservation. Moreover, despite strong efforts by the city to promote rainwater harvesting systems, only 5% of households report having installed such systems.

Legal Framework

Importantly, legal mechanisms including economic instruments can play a very important role in impacting consumer behavior and decision-making to better optimize water use in Jaipur. Rajasthan state has made two important policy declarations in the recent past. The Rajasthan State Water Policy (2010) and Rajasthan State Environmental Policy (2010) complement each other very well to promote water use efficiency. The State Action Plan for Climate Change (2011) further reinforces the policies. Amendments have also been made to the Municipal Act and other directives issued by the Urban Development and Housing Department, Government of Rajasthan (GoR), in 2009 to ensure the adoption of water conservation measures in domestic and commercial sectors. The Jaipur Development Authority (JDA), responsible for infrastructure development, and Jaipur Nagar Nigam (JNN), responsible for operation and maintenance of municipal services, have joined hands to achieve similar objectives. However, the level of compliance with required water efficiency rules remains weak generally, and much more can be done to effectively implement water legislation geared toward efficiency.

Based on WAISP's analysis and findings, several opportunities to improve water use efficiency in Jaipur were identified to thereby better assure future growth of the city while meeting the competing water needs for human welfare, agriculture and food security, industry and economic growth.

Opportunities

Based on WAISP's analysis and findings, several opportunities to improve water use efficiency in Jaipur were identified to thereby better assure future growth of the city while meeting the competing water needs for human welfare, industry and economic growth. WAISP considered inter-related opportunities for action, noting

[1] Dual flush toilets have two flush valves, enabling the user to save water by reducing the volume of flush water for liquid waste flushes.

potential projects, technology options, as well as legal reforms. Specific projects have been proposed, such as considering recycling water used for washing railway coaches and buses in the maintenance sheds. The required technology would remove grease and dirt rather than full tertiary treatment to drinking water standards. Also, the fabric dyeing and garment industry in Sanganer uses large quantities of water. The discharge from these units can be treated and reused by installing combined sewage treatment plants and reusing the water for agricultural purposes. Another treatment technology already in use in India and worthy of more serious consideration includes root zone treatment[2], which is less energy intensive and hence often more cost-effective.

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Opportunities for legal mechanisms, such as mandatory labeling of water fixtures and appliances, and establishing maximum flow rates, are necessary to educate consumers and developers to select appropriate equipment in this water scarce region. Rebates, taxes, and other economic instruments can be used to encourage the use of efficient equipment, and discourage use of inefficient equipment. In addition, establishing a water demand management unit within the Public Health Engineering Department (PHED) or JDA could be highly beneficial. Such a unit could support municipal level conservation efforts through outreach campaigns, assist with enforcement, and engage users through technical assistance. Considering that water recycling and reuse efforts are currently being undertaken on the basis of a given individual's understanding of the range of available options, a guidance manual is also recommended. Something similar to the Central Public Health Environment Engineering Organization (CPHEEO) manual, focusing on wastewater reuse, and the appropriate parameters to enable agricultural irrigation, construction activities, water for cooling towers, or for flushing in water closets, would assist and encourage more municipalities to adopt such initiatives.

Conclusion

Jaipur city is located in a region which is semi-arid and vulnerable to water scarcity given the existing water supply-demand imbalance. It has traditionally depended heavily on groundwater, which has been overdrawn far beyond sustainable levels. The water related stress in Jaipur is likely to be exacerbated by climate change events in the region. Introducing efficiencies in water use are therefore imperative for the city's growth. The national policy framework as well as state-specific regulations and policies suggest that policy makers and municipal administrators are sensitive to the emerging threat, and that an enabling environment for action exists.

[2] Also called "constructed wetlands," these are man-made wastewater treatment systems designed with natural processes as found in natural wetland ecosystems, relying on plants, soil and microbial life to treat waste.

I. INTRODUCTION

The Water Analysis, Innovations, and Systems Program (WAISP) is funded by the U.S. Agency for International Development (USAID/India). The overall goal of the program is to increase the security of potable water supply and sanitation services by building resiliency to global climate change and advancing sustainable approaches to multiple use water services provision for potable and productive applications.

WAISP began by conducting a water sector assessment of eight states in India, which looked specifically at water vulnerability in relation to climate change, food security, and health (available as separate report completed June 2011). The program then carried out three city-level analyses for ways to improve water efficiency in representative cities—Faridabad, Jaipur, and Pune—which were identified as having potential for national replication.

For USAID/India, the inter-linkages between water resources and climate change, food security, and health are of paramount importance. India faces multiple challenges relating to competing uses of scarce water resources—between household and municipal consumption, agriculture, industrial, and ecosystem services. Furthermore, projected impacts of climate change indicate a higher variability in precipitation, with more frequent droughts and floods, and general stress on the hydrologic regime. Unrestricted groundwater exploitation by all sectors in the absence of adequate regulation and pricing is already severely impacting water scarce areas.

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For the second program component, WAISP conducted a series of consultative meetings with USAID, the Confederation of Indian Industry's (CII) Triveni Water Institute, and officials within various municipalities. The guiding principles for selecting Faridabad, Jaipur, and Pune were: (1) water scarcity with high potential for growth; (2) feasible within a one-year time frame; (3) enables donors and the municipalities to follow-up with longer-term initiatives based on the results; (4) interest of municipal authorities to focus on the interface across the urban built environment and industry; (5) linkages with CII's networks for follow-up.

The results of WAISP's second component are presented in three separate reports, one for each city—Faridabad, Jaipur, and Pune—as a *Guideline for Water Use Efficiency*. This document represents the Guideline for Jaipur and includes a city profile and background, review of the water supply and sanitation infrastructure, as well as their vulnerabilities to potential climate change impacts, analysis of the legal and policy framework related to water, as well as survey results on water use trends in the city. The report concludes with a review of recommended opportunities to improve urban water use efficiency, and a reference compendium of relevant Indian and international case studies. This Guideline is designed to serve as a decision-support resource for municipal officials to better understand and address the existing water stressed condition in Jaipur.

The Plan document quotes estimates of the "2030 Water Resources Group" which indicates that if current demand patterns continue, about half of the demand for water will be unmet by 2030, and therefore recommends a paradigm shift and reform agenda to address the challenge.

National Context

Water is a "State" subject in the Indian Constitution, which means that states are free to pursue their own policies regarding its use, and have exclusive power to legislate on this subject.[3] The central government provides funds to states from its budget to improve water resource management and has an advisory role in this sector, which flows from the issuance of guidelines. The Draft National Water Policy of June 2012 states: "Even while it is recognized that States have the right to frame suitable policies, laws and regulations on water, there is a felt need to evolve a broad over-arching national legal framework of general principles on water to lead the way for essential legislation on water governance in every State of the Union and devolution of necessary authority to the lower tiers of government to deal with the local water situation" (GoI, 2012a).

Previously, the Government of India's Approach Paper for the 12th Five Year Plan (2011) observed "It is necessary to match our use, through improvement in efficiency, with the annual replenishable water supply that the country receives. Available evidence suggests that with increased use of water, mostly on an unsustainable basis, the country is headed towards a grave water crisis" (GoI, 2011). The Approach Paper commented, "…the real solution has to come from greater efficiency in water use." It also emphasizes the need to establish a National Water Commission (NWC) to monitor compliance with the national water strategy.

Following this approach, the Twelfth Five Year Plan (2012-2017) released by the Planning Commission, Government of India, has analyzed the water situation generally, and in the specific context of industry. The Plan document quotes estimates of the "2030 Water Resources Group" which indicates that if current demand patterns continue, about half of the demand for water will be unmet by 2030, and therefore recommends a paradigm shift and reform agenda to address the challenge. Among other things, this shift includes "definite targets for recycling and reuse of water by Indian industry to move in conformity with international standards" (GoI, 2012c).

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[3] However, the national Parliament has the power to legislate the regulation and development of interstate rivers.

Recycling wastewater for industrial use has been advocated as it not only helps in conserving fresh water, but also reduces the quantum of untreated wastewater discharged to common water bodies, which causes environmental degradation and compounds the disease burden. Nationally, over 70 percent of municipal wastewater is discharged untreated into rivers and waterways, with severe health implications from biological contamination. Also, while the Environmental Protection Act of 1986 mandates that all industrial effluents be treated prior to disposal, statistics indicate that toxic effluents to the tune of 40 percent go untreated into mainstream water bodies, causing chemical contamination with risks to human health, environment, and agriculture.

The agenda for reforms in the 12th Plan will have four thrust areas:

- Agenda 1: Focus on demand management, reducing intra-city inequity and on quality of water supplied

- Agenda 2: Protection of water bodies

- Agenda 3: Water supply scheme conjoined with a sewage component

- Agenda 4: Recycling and reuse of treated wastewater

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Additionally, the Plan document acknowledges the need for industries to adopt international best practices to improve water use efficiency. It suggests two ways in which this can happen:

- Reducing the consumption of fresh water through alternative water efficient technologies or processes in various manufacturing activities; and

- Reusing and recycling wastewater from water intensive activities, and making the reclaimed water available for use in the secondary activities.

A recent Advisory Note from the Ministry of Urban Development recognizes the threat to both quantity and quality of water resources in the country resulting from rapid urbanization and underscores the need to collect and treat wastewater, which would contribute to managing the finite resource more effectively (GoI, 2012b). The note highlights two key emerging challenges in the water sector: first, to ensure environmental and financial sustainability; and second, to ensure equitable service provision, especially to the urban poor. The following recommendations from the Working Group on Urban Water Supply and Sanitation for the 12th Plan cited in the Note are significant:

The Ministry of Water Resources is also taking steps to establish the National Bureau of Water Use Efficiency... Some of the approaches under consideration include scaling up water recycling, artificial groundwater recharge, and enlarging the scope of activities for treated wastewater reuse.

- Careful assessment of the total cost of the water and sewage sector is required to ensure that projects are planned in an affordable and sustainable manner.

- Water and sewage services must be paid for in order to recover costs.

- Future investments in water supply should include elements of demand management (reducing water usage) and distribution system leakage management to help reduce intra-city inequities in both quantity and quality of water supplied.

- Building, renewing, and replenishing local water resources, including groundwater, to cut costs of water supply through investments in sewerage and in increased reuse and recycling of wastewaters.

- Building capacities at all levels, including exploring institutional and management options for improved water and sanitation provision in cities.

The broad objectives of conserving water, minimizing wastage in use, and ensuring more equitable distribution are also reiterated in the Mission statement of the National Water Mission (NWM)—one of the eight Missions created as part of the National Action Plan on Climate Change (NAPCC). The National Water Mission intends to achieve this objective through integrated water resources development and management.

The Ministry of Water Resources is also taking steps to establish the National Bureau of Water Use Efficiency. When established, the Bureau will work to reduce distribution losses (non-revenue water) in domestic utilities. The Bureau will also seek to demonstrate approaches to achieve 20% water use efficiency improvements across water uses (domestic, industrial, commercial, irrigation), and will offer incentives to achieve this level of water savings. Some of the approaches under consideration include scaling up water recycling, artificial groundwater recharge, and enlarging the scope of activities for treated wastewater reuse.

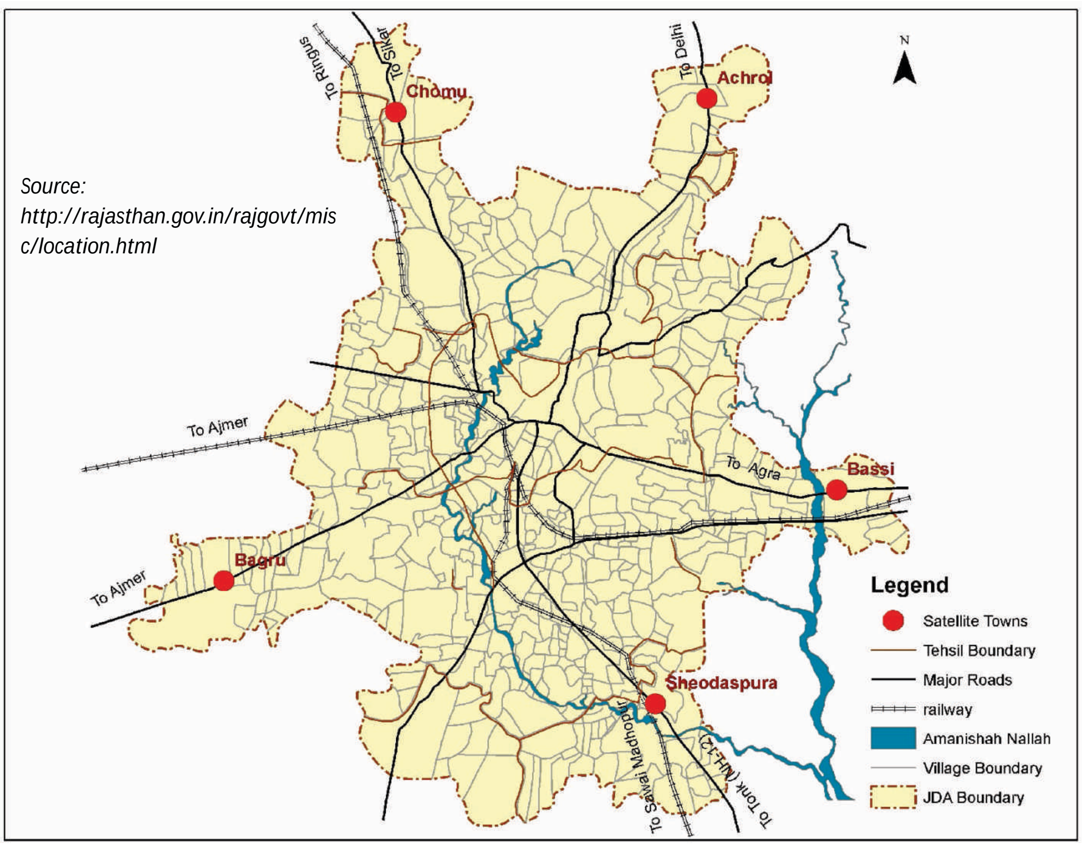
In the following sections, the characteristics of Jaipur city, vulnerability to the effects of climate change, hydrology, current water and sewerage conditions, water use practices, and opportunities for water conservation are presented. Recommendations for specific opportunities deserving further attention and analysis, and best management practice concepts are offered as part of this project, based upon on-site observations, discussions with water authorities, and the results of the water use survey conducted.

Jaipur City Profile

The state of Rajasthan is located in the northwestern part of the Indian subcontinent. Rajasthan is largely a desert, and one of the driest states in India, particularly in the western areas, known as the Great Indian Desert or the Thar Desert. Jaipur, the capital city of Rajasthan state, was established in 1727 by the Rajput ruler Sawai Jai Singh II, who moved the capital of his kingdom from Amber because of acute water shortage. Unlike many other old cities of the period, Jaipur is characterized by carefully planned land use and an adequate water supply system. Some of the original construction dating back to the early 18th century still remains with very little modification in what is referred to as the "Walled City". It is known for its unique style of architecture and the pink color of its historical buildings. The city is at an altitude of 431 meters, with a flat topography and well-planned layout of streets and roads on a grid pattern.

Figure 1: Location of Jaipur in Rajasthan

Figure 2: Jaipur Development Authority Region



Rajasthan has been urbanizing rapidly in recent decades. Jaipur has a population of 3.07 million as per the 2011 Census. The population had been growing at a rate of approximately 50% or more every 10 years until 2001, at which point population growth slowed somewhat.

The Jaipur Development Authority (JDA), established in 1982, is responsible for infrastructure development within the city. From its mere 40 km^2 area in 1951, the JDA region extends today over an area of 1,464 km^2. It comprises the following spatial units:

- The Jaipur Municipal Corporation (JMC) that includes the walled city and the rest of JMC.
- The rest of JDA area that includes satellite towns and villages.

In order to encourage planned development in the city, the JDA has prepared two master plans to date. The first master plan for 1971-1991 came into effect in May 1976, and included 125 revenue villages along with the Jaipur Core City, including six satellite towns. Jaipur was envisaged principally as an administrative, commercial, and distribution center for the state, and was proposed to be developed as a major tourist destination. The Jaipur Development Authority (JDA) prepared a second Master Development Plan for the Jaipur Region, finalized in August 1998, projecting to horizon year 2011. A third Master Development Plan has now been approved by JDA with horizon year 2025.

Population and Growth Trends

Rajasthan has been urbanizing rapidly in recent decades. Jaipur has a population of 3.07 million as per the 2011 Census. The population had been growing at a rate of approximately 50% or more every 10 years until 2001, at which point population growth slowed somewhat. This rapid population growth contributes to the shortage of water supplies for the population and for all the supporting industry and agriculture that serves the needs of the community. Table 1 below shows the population of Jaipur city and the growth over the last three decades.

Table 1: Population Growth in Jaipur City During Last 30 Years

Year	Population	Growth Rate
1981	1,010,000	59%
1991	1,518,235	50%
2001	2,322,575	53%
2011	3,073,350	32%

Source: Census of India

Industrial and Bulk Water Users

Some of the main industries in Rajasthan include textiles, gem polishing, rugs, woolen goods, vegetable oil, dyes, as well as heavy industry such as copper and zinc smelting, manufacturing machinery, steel, cement, ceramics, and glassware. Industrial activities in Jaipur are scattered geographically across the city. A few industrial areas exist in the city, namely Jhotwara Industrial Area, toward the North-West of the city; 22 Godam Industrial Area; Vishwkarma Industrial Area on Sikar road toward the north of the city; textile industries concentrated in Sanganer toward the south; Malaviya Industrial Area; and Sitapura Industrial Area toward the south-east, now occupied by institutional activities. The industrial base in Jaipur can be separated into three categories:

- Regulated main industries located in designated industrial areas
- Regulated small scale industries (SSI) located in industrial areas
- Unregulated cottage industries in scattered locations

Regulated industries are those which are formally registered and licensed, while unregulated industries operate with no official registration, and therefore generally with little to no regard for regulations, including environmental provisions.

The earliest industries to be established in Jaipur are located in the Ram Mandir area, near Jaipur Junction, the main railway station. Industrial development spread with the formation of the Rajasthan State Industrial and Development and Investment Corporation (RIICO) in 1979. The current Red Category List[4] of industrial and commercial establishments includes 23 industrial premises, 21 hospitals, and 16 hotels.

Most of the main industries operate under extremely difficult conditions because of the chronic shortage of water. Many industries have their own tube well to extract groundwater and augment their municipal water supply to ensure continuity of operations. This contributes to groundwater over-exploitation as evidenced by lowering groundwater levels in Jaipur. There are a limited number of large water-consuming industries in Jaipur, and the Rajasthan State Pollution Control Board (RSPCB) generally regulates and monitors those that are located

Industrial activities in Jaipur are scattered geographically across the city... Some of the main industries in Rajasthan include textiles, gem polishing, rugs, woolen goods, vegetable oil, dyes, as well as heavy industry such as copper and zinc smelting, manufacturing machinery, steel, cement, ceramics, and glassware.

[4]All hazardous, noxious, heavy and large industries as set by the Central Pollution Control Board are categorized under the Red Category.

within the city. Overall, wastewater flows and pollution loads vary by industry, as do treatment and disposal methods. Discussions with the Public Health Engineering Department (PHED) and other officials, suggests that some large industries perform on-site wastewater treatment.

Tourism is the most important economic activity in Jaipur—it is among the most important tourist destinations in India. In addition to the direct economic contribution of the hospitality industry, tourism has an important multiplier effect on other commercial activities and service sector. Hotels across the city cater to every taste and budget, ranging from deluxe to the modest budget accommodations.

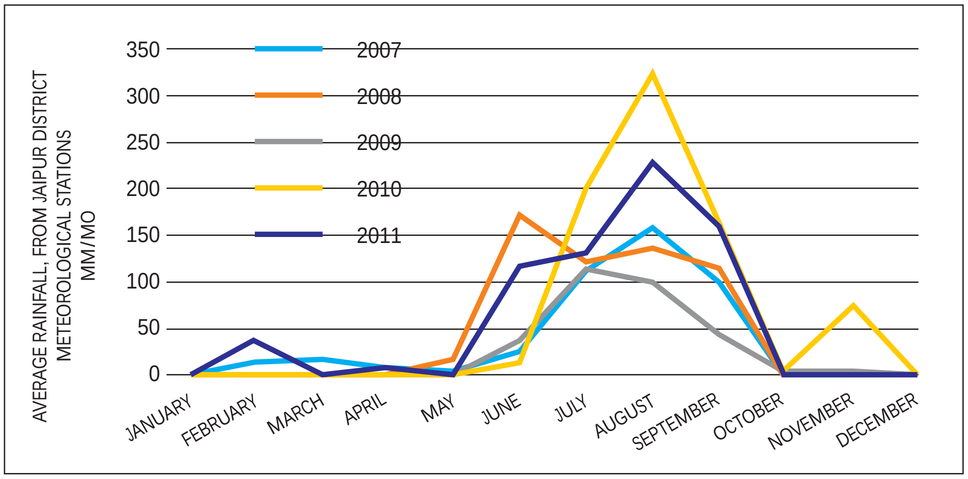
Textiles and gem polishing are the other important industrial activities in Jaipur. In Sanganer municipal zone in the southern part of Jaipur city, dyeing and block printing is a household industry. The block prints are famous throughout India for the dyeing technique used. This activity consumes a lot of water, and the wastewater is also suspected to pollute groundwater aquifers in the area. The textile industry in Sanganer historically used vegetable dyes, but these have almost entirely been replaced with cheaper and easily available inorganic dyes. Manufacturers dispose of the large volumes of liquid waste generated by the dyeing and printing process in open water drains known as *nallas*. The liquid wastes are also used by farmers for irrigation. Unused effluent wastes accumulate in the peripheral areas, and over time they percolate and contaminate the saturated zone. Whereas organic dyes have shown fluoride content of 0.2 to 1.8 parts per million (ppm), the current effluent wastes have much higher fluoride content of 1.6 to 7.7 ppm (Srivastava et. al., 2011).

2. WATER SUPPLY AND CLIMATE CHANGE VULNERABILITY

Hydrologic Setting

The climate of Jaipur is semiarid, and average annual rainfall is only 650 mm (26 inches). Most rain occurs during the monsoon season between June and September, when heavy rains and thunderstorms are common. Annual rainfall, averaged from data collected at all the meteorological stations over a five-year period in Jaipur District, is depicted in Figure 3. The temperature in Jaipur varies from 25° C to 45° C in summer months, and from 8° C to 22° C during winter.

Figure 3: Rainfall Pattern in Recent Five-Year Period in the City of Jaipur



Source:
India Meteorological Department

There are two water bodies—Ramgarh and Bisalpur—formed by dams, providing about two-thirds of the drinking and irrigation water to the city. In recent years, water levels in these lakes have dropped due to variable rainfall in the catchment. Jaipur also depends on a chain of 1,826 deep, large diameter tube wells drilled by the PHED.

The entire city of Jaipur lies within a "dark" zone on the hydrological map of the region, meaning that the area is overexploited. Groundwater levels have been declining rapidly in recent years due to overdraft—withdrawal beyond the safe yield (Jethoo, 2011). It is estimated that the water table is falling at the rate of between 1.5 to 3 meters per year due to over exploitation, and is now between 65 to 70 meters below ground in most areas. The withdrawal level is estimated to be 600% of the safe yield (Sunda, 2012). Lack of coordination among competing uses, and the absence of effective regulation have caused this situation. The fact that water is not priced according to its cost has only further promoted the misuse of water resources. Many industries have their own tube wells to augment their PHED provided water supply to ensure that their factories continue to operate.

Water Supply and Delivery Infrastructure

When the city was established in 1727 AD, residents obtained drinking water from large public wells.[5] Piped water supply for the general population began in Jaipur in 1874 with the construction of a 4.5 ML capacity reservoir across Amanisha Nalla. The Ramgarh Dam was built in 1906 and supplied water to the city until 2000. The capacity of the lake was increased in stages to 72 ML. By 1971, the city population had grown to a level which could not be served with only surface water from Ramgarh Lake. Therefore, Jaipur developed several groundwater sources, adding a combined capacity of 63 million liters/day (MLD) from wells. Later, in 2010, the piped water supply system from Bisalpur Dam, located 117 km away from Jaipur, was commissioned; it currently provides 262 MLD (against a total installed capacity of 600 MLD). However, supply from the Bisalpur Dam has been erratic during its brief life because of variable rainfall in the catchment.

Stream near fabric dyeing industries with heavily polluted water used by nearby farmers for irrigation.

Photo: Bahman Sheikh

The PHED is responsible for creating the water supply infrastructure, while the Municipal Corporation is responsible for operations and maintenance. The total demand for treated water in Jaipur city is estimated to be 415 MLD, using the Service Level Benchmark (SLB) of 135 liters per capita per day (Lpcd) and the population as per the 2011 Census. Table 2 below summarizes the water supply and demand situation in Jaipur city.

Below: Typical baori in Jaipur, this one currently recharging groundwater.

Photo: Dipak Roy

Table 2: Water Demand and Supply in Jaipur City

Description	Quantity
Total Population of Jaipur City	3.07 million
Total Water Demand	419.7 MLD
Total Water Supplied	413.0 MLD
Water Supplied to Villages	40.0 MLD
Water Supplied to City	373.0 MLD
Non-Revenue Water	30% (108 MLD)
Net Water Received by City	252.0 MLD

Source: PHED, Jaipur (Unpublished report of February 2012)

[5] Typically these were "step-wells" (called Baoris in local parlance). Some of the Baoris survive today and are preserved as archaeological relics.

Water supply coverage via the piped network in Jaipur city varies between 91% and 95%, with a per capita supply of 85 liters, based on figures from PHED. On average, water is supplied for 1.5 hours per day. Only few areas in the city receive continuous water supply.[6]

Private vendors sell drinking water via tanker trucks to customers throughout the city. The tanker trucks are usually filled from privately held pumped groundwater at various locations throughout the city. Because of the significantly higher cost of this source, it is limited to the relatively high-income segment in the city. It is estimated that this source meets about 10% of water demand in Jaipur.

Many private wells have been built and are in use today. However, additional wells are prohibited, except in cases where communities or residents do not have municipal drinking water access. In the future, more strict control of groundwater use by private businesses and individuals will be necessary to ensure its sustained availability for the community through the municipal water supply system.

With respect to water tariffs, the PHED Rajasthan established water rates in May 1998 and classified all consumers into three categories: a) Domestic, b) Industrial, and c) Non-domestic. The last category includes all users not included in the first two categories (commercial users such as shops, offices, hospitals, private educational institutions, cottage industries, restaurants and *dhabas*, cinemas, dairy units, building construction sites, marriage halls, nurseries, railway/bus stands, laundromats, etc.). Hotels, though, are considered "industrial" users.

The 1998 water rates remain in effect. Table 3 summarizes the basic tariff structure.

Table 3: Water Tariffs in Jaipur City

Category of consumer	Minimum charges per month	Flat rate charges per month for unmetered connections (Rupees)	Charge per 1,000 liters for metered connections (Rupees)		
			< 15,000 L	15,000-40,000 L	> 40,000 L
Domestic	Rs. 20 for a 15 mm connection; Up to Rs. 11,245 for 150 mm connection	Rs 20	1.56	3.00	4.00
Non-domestic	Rs. 51 for a 15 mm connection; Up to Rs. 11,245 for 150 mm connection	Not applicable	4.68	8.25	11.00
Industrial	Rs. 120 for a 15 mm connection; Up to	Not applicable	11.00	13.75	16.50

[6] Mansarovar (Sectors 1, 3, 9) and Malaviya Nagar (Sector 9), receive continuous water supply. PHED is also planning to extend continuous service to 13 more areas: Nehru Nagar, Kanwar Nagar, Sethi Colony, Jawahar Nagar, Janta Colony, AG Colony, Jyoti Nagar Housing Board Colony, Sector 2 of Malaviya Nagar, Himmat Nagar, Sectors 9 & 10 of Mansarovar, Vaishali Nagar (D Block), Sectors 1,2,3 of Chitrakoot, Sectors 5, 51 & 52 of Pratap Nagar.

The city has a capacity of sewage treatment of 202 MLD, and is currently expanding this to add another 60 MLD. Other areas use septic tanks for disposal of human wastes. In 1998 it was estimated that 120,600 septic tanks were in use in Jaipur, serving about 25 percent of the city's population.

The PHED reports a total of 344,090 functional water supply connections as of February 2010, and of these, 98% are metered. Compared to other Indian cities, this is a positive feature.

The cost recovery in the supply system was estimated at 40% for the period 1998-2001 (PWC, undated) in a report prepared on the reforms agenda of the state, which looked at the urban water and sanitation sector. It points out that tariffs and costs are not aligned, and there is a need for an independent regulatory framework outside the PHED. The PHED Jaipur estimates the volume of non-revenue water (NRW) at 36 percent.

Wastewater Infrastructure

The central parts of Jaipur are served with a sewerage system, including a network of sewers collecting wastewater from about 65 percent of the city's area. The city has a capacity of sewage treatment of 202 MLD, and is currently expanding this to add another 60 MLD. Other areas use septic tanks for disposal of human wastes. In 1998 it was estimated that 120,600 septic tanks were in use in Jaipur, serving about 25 percent of the city's population.

Basic sanitation facilities are absent in most of the slums and *katchi bastis* (shacks or non-permanent structures). Most of these places have neither sewerage systems nor septic tanks. There are about 76 community latrines throughout Jaipur catering to the slums and general public, which is much below the requirement. As a result, most slum dwellers resort to open defecation along the roads and open drains, polluting the surroundings, which also results in risks to human health.

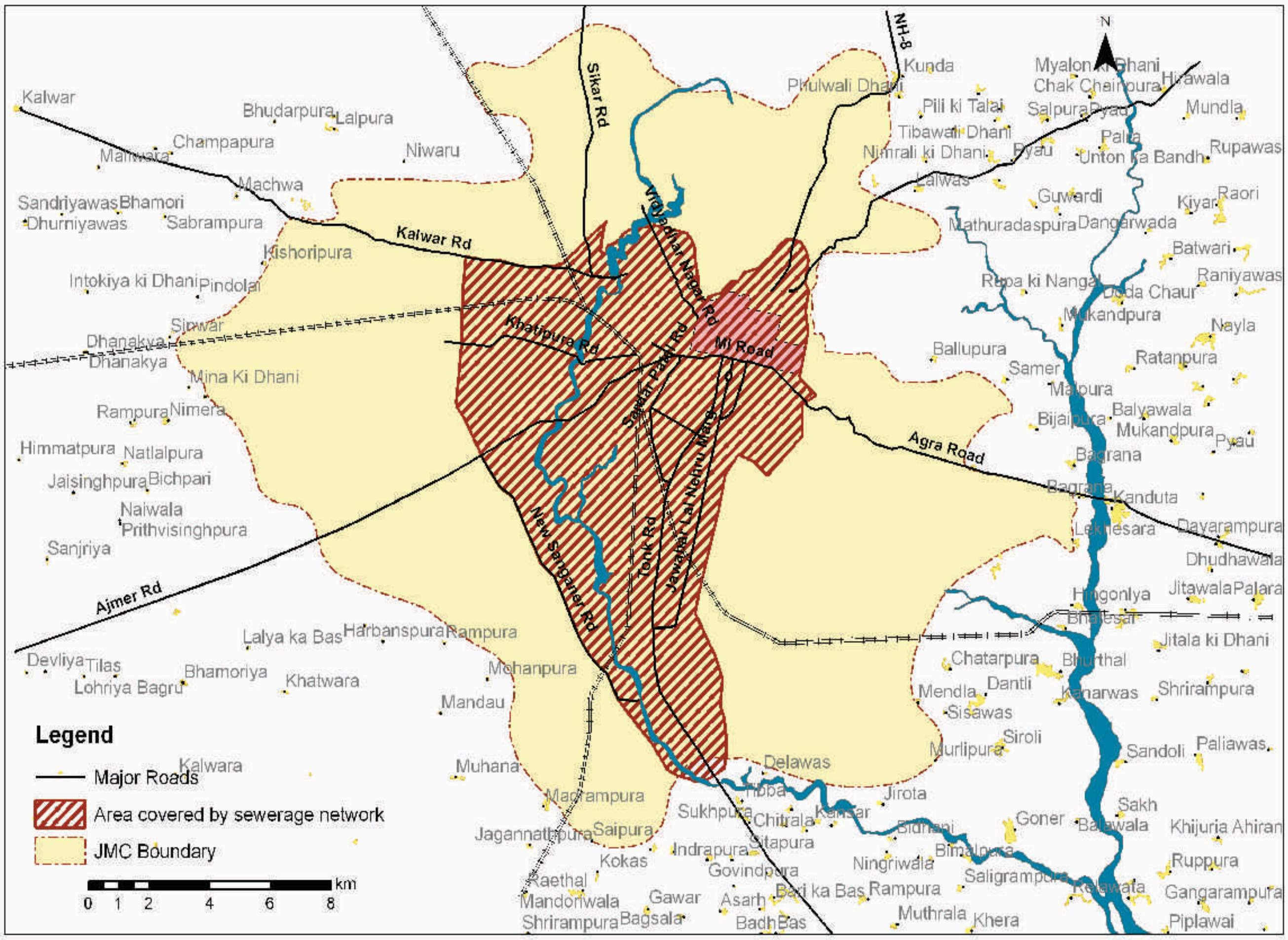
Figure 4 depicts the sewerage network coverage in Jaipur city. There are five major Sewage Treatment Plants (STPs) in Jaipur.

Table 4 below shows the jurisdictional location of the wastewater treatment plants and their capacities.

Table 4: Wastewater Treatment Capacity in Jaipur City

Jaipur Nagar Nigam Jurisdiction	JDA Jurisdiction
Barhampuri – 27 MLD	Ralawata – 30 MLD (under construction)
Jaisinghpura – 50 MLD	Gajadharpura – 30 MLD (under construction)
Delawas – 125 (62.5 + 62.5) MLD	

Figure 4: Sewerage Network Coverage in Jaipur City



The entire area under the Jaipur Municipal Corporation—referred to as Jaipur Nagar Nigam (JNN) —is served by the wastewater collection network and two wastewater treatment plants in the north at Brahampuri and Jaisinghpura Khor on Delhi road, and at Delwas in south Jaipur. Jaipur Nagar Nigam is also planning to provide 20 MLD of treated water from Delwas STP to Mahindra Special Economic Zone (SEZ) for non-drinking uses, such as irrigation for gardening, firefighting, etc.

In addition, JNN has given Man Sagar Lake on lease for a period of 99 years to the Kothari Group, a business enterprise that has established a water treatment plant for its own use, and also supports conservation of the lake (see case study on page 59). JDA also plans to increase the capacity of the Vidhyadhar Nagar STP, and proposes a new plant in Vaishali Nagar. However, the tributary areas of Bambala Pulia and Kho Nagoriyan are not served with a wastewater treatment facility.

Table 5 below provides details of wastewater reuse from STPs at three different locations in the city.

Table 5: Wastewater Treatment Plants Reusing Treated Water for Irrigation of Gardens

Location	Capacity of STPs, MLD
Ramniwas Garden	1
Jawahar Circle Garden	1
Swarna Jayanti Park in Vidhydhar Nagar	1 (under construction)

Summary of Climate Change Vulnerability

The Intergovernmental Panel on Climate Change (IPCC) developed a set of scenarios for greenhouse gas emissions in the future world taking into account different directions of demographic change, economic development, and technological change. Four different storylines called A1, A2, B1, and B2 were developed with different assumptions.

Globally, the issue of sustainable freshwater availability is expected to be exacerbated by climate change (Bates, 2008), and the adverse impacts of a changing climate makes achieving development objectives all the more difficult. Locally, the hydrologic profile of Jaipur illustrates significant water stress, with important vulnerabilities in the short and long-term due to climate change.

The Intergovernmental Panel on Climate Change (IPCC) developed a set of scenarios for greenhouse gas emissions in the future world taking into account different directions of demographic change, economic development, and technological change. Four different storylines called A1, A2, B1, and B2 were developed with different assumptions. Of these storylines, the A1 scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies (IPCC, 2000). The A1 scenario family further develops into three groups describing alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B).

Climate change scenarios for India under the A1B scenario of emissions project a warming on the order of 0.5^0 to 1.5^0C in the 2020s and up to 3^0C in the 2050s, against the baseline of the 1970s. Climate models further project that the maximum warming is expected over the northern parts of India and over the Himalayas (Indo-UK, 2012), with an increase in seasonal (monsoon) rainfall of 10% in the 2020s and 15-20% in the 2050s, against the 1970s baseline.

An analysis of one-day extreme rainfall series based on historical meteorological records in India showed an increase in intensity of extreme rainfall over Gujarat (Saurashtra and Kutch), East Rajasthan, coastal Andhra Pradesh, Orissa, West Bengal and parts of northern India (Indo-UK, 2012). The study also concluded that there was a significant decrease in intensity as well as frequency of rainfall over Chhattisgarh, Jharkhand, and some parts of north India.

Jaipur falls in the East Rajasthan region and therefore, projected increases in warming and rainfall per the A1B scenario of development are considered applicable to the city. In addition, the intensity of rainfall is also projected to increase for the city.

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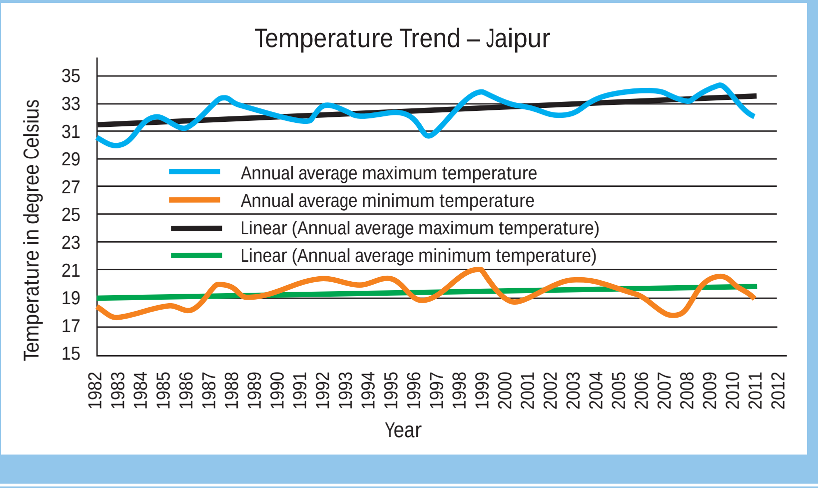
It is important to note that significant variability in forecasts can occur across the different storylines, and based on different scales of analysis (such as global, regional, local). For purposes of this report, in order to assess the water resource-related vulnerabilities due to climate change[7], climate events affecting water resources for Jaipur were first identified. Then, the probability of occurrence of these events in the city was determined. The probability of occurrence is the likelihood that such an event may occur, based on a scale of low/medium/high, as presented in Table 6. Upon determining the nature of the impacts from these events (Table 7), the municipality's preparedness is considered to mitigate these impacts.

[7] The IPCC 2000a publication defines vulnerability as “the extent to which a natural or social system is susceptible to sustaining damage from climate change, and is a function of the magnitude of climate change, the sensitivity of the system to changes in climate and the ability to adapt the system to changes in climate.”

Table 6: Probability of Occurrence of Certain Climate Change Events for the City of Jaipur

Climate Events	Probability of Event	Rationale
Scanty rainfall in rainy seasons	**Low**	Several climate studies report a general trend of a decrease in the number of rainy days and total annual amount of precipitation in many Asian countries.[8] From the monsoon data on the India Meteorological Department's website, the East Rajasthan area has mostly received normal rainfall between 2005 and 2012, with one deficient monsoon year in 2009, and excess rainfall in 2011.[9] The recent trend indicates that there is a low probability of occurrence of scanty rainfall in the monsoon season, given that the region itself is in a semi-arid zone.[10]
Wetter non-rainy seasons	**Low**	The Jaipur area and the Banas river basin receive the bulk of their rainfall in the monsoon months from June to September. There has been no exclusive study or indication of an increase in off-season rainfall in the area.
Hotter summers	**Medium**	The general trend of annual average maximum and minimum temperatures of Jaipur since 1982 indicates a gradual warming in the region.[11] The trend is in line with the projection made by the climate change model for India. Thus, the probability of increasing summer temperatures is estimated as “medium”. 
Storms and intensive rainfall	**Medium**	Many studies report that the frequency of occurrence of more intense rainfall events in many parts of Asia has increased in general.[12] The climate change model for India projects both an increase in quantum of seasonal rainfall and intensity of rainfall in the monsoon months in East Rajasthan region (Indo-UK, 2012). Therefore, the climate event is designated a "medium" probability event.

[8] Zhai, 1999; Khan, 2000; Shrestha, 2000; Lal, 2003; Ruosteenoja, 2003; Zhai, 2003; Gruza, 2003.

[9] See http://www.imd.gov.in/section/nhac/dynamic/Monsoon_frame.htm, and http://www.imd.gov.in/section/nhac/dynamic/weekly_pressrelease.pdf

[10] See Agro Climatic Region, Department of Agriculture and Cooperation, http://dacnet.nic.in/farmer/new/dac/AgroClimaticZones.asp?SCod=17

[11] See average annual climate values, Jaipur, http://www.tutiempo.net/en/Climate/Jaipur_Sanganer/423480.htm

[12] Khan, 2000; Shrestha, 2000; Lal, 2003; Ruosteenoja, 2003; Zhai, 2003; Gruza, 2003, and http://www.imd.gov.in/section/nhac/dynamic/Monsoon_frame.htm

Impacts of Potential Climate Events on the Municipality of Jaipur

The following Table 7 presents the possible impacts from each of the high and medium probability climate events for the city of Jaipur, with further discussion below.

Table 7: Potential Impacts and Vulnerabilities to Climate Change Events

Climate events related to Jaipur	Potential Impacts	Vulnerability	
		Short Term (2020s)	Long Term (2050s)
Scanty rainfall in rainy seasons	Reduced recharge, droughts	**Medium**	**High**
Wetter non-rainy seasons	Water logging, floods	**Low**	**Medium**
Hotter summers	Reduced recharge, droughts	**Medium**	**High**
Storms and intensive rainfall	Water logging, floods, reduced recharge	**Medium**	**High**

Reduced Recharge

As per the stage of groundwater development (percentage of annual groundwater draft to net annual groundwater availability) assessed in 2004, Jaipur falls in the 'overexploited' category, with a groundwater development of 600% (Sunda, 2012). This indicates a significant long term decline in pre-monsoon and post monsoon levels of groundwater in the area. Currently, the municipality supplies 413 million liters a day against the demand of 419.7 million liters a day, and deep tube wells in the city contribute 37% of the water supply.

Nitrate pollution in groundwater has been reported in the urban areas of Jaipur city, with high fluoride and high salinity levels recorded in parts of Sanganer, Chaksu, Dudu and Phagi blocks (CGWB, 2007). While high fluoride levels could be of geogenic origin, over extraction of groundwater could exacerbate the condition.

In order to address the issues of reduced recharge and overexploitation of groundwater, measures such as restricting exploitation of groundwater, enabling groundwater recharge through harvesting and channeled percolation of rainwater may be adopted. The state government and city of Jaipur have taken a number of associated steps. For its part, the Government of Rajasthan has declared that drilling tube wells is strictly prohibited in the overexploited 'dark zone'. For any new tube well drilling, permission from the District Collector is required. The Groundwater Department (GWD), in partnership with residential colonies in

Jaipur, has taken up renovation work on rainwater harvesting structures such as *Baoris* and tanks, in addition to tube well rejuvenation projects. Rainwater harvesting structures are installed in government buildings and institutes such as the State Assembly (*Vidhan Bhavan*), and the Secretariat building (*Vittal Bhavan*). The Jaipur Development Authority (JDA) has constructed around 142 rain water harvesting structures throughout the city, and 40 others are under construction.

The JDA building bylaws of 2010 envisaged water recycling and a water harvesting system, applicable across Jaipur (Indo-UK, 2012). GWD also undertakes public awareness campaigns through seminars, workshops and other media about water harvesting, and also provides plans and designs for rain water harvesting to those interested.

The Jaipur City Development Plan of 2025 projects that the population of the city would reach 7.56 million in 2025, and the corresponding water demand would be 1,224 million liters a day (Indo-UK, 2012). Therefore, it is reasonable to assume that the demand would be a lot higher than 1,224 million liters a day in the 2050s. Considering sewage generation at about 80% of supply, about 980 million liters a day of sewage will be generated. Currently, however, there is sewage treatment capacity of reaching 262 million liters a day, and this treated sewage is ultimately discharged to the Dhoond River. This implies that the city's demand for both freshwater supply and wastewater treatment infrastructure would increase beyond its current serviceable capacities in the 2050s.

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In sum, while the city of Jaipur has a high and growing dependence on groundwater reserves to meet its water needs, the city has also taken notable measures to reduce groundwater exploitation and recharge the system. Furthermore, the supply of water from the Bisalpur Dam will help meet the city's water demands in the near term. In the longer term, the potential for scanty rainfall and hotter summers present notable risks. Therefore, the vulnerability of the city to reduced recharge is “medium” in the short term, but can be significant over the long term.

Droughts

The Indian Meteorological Department defines 'meteorological drought' as a situation when the deficiency of rainfall at a meteorological sub-division level is 25% or more of the long-term average of that sub-division for a given period. The drought is considered 'moderate', if the deficiency is between 26% and 50%, and 'severe' if it is more than 50% (Dourte, 2012).

The district area of Jaipur is said to be prone to drought spells as witnessed during 1984 to 1989 and 1999 to 2002, according to a study by the Central Groundwater Board (NRSC, undated). The recurrence of drought in Jaipur is estimated to be once in five years as per the Drought Management Manual of the State of Rajasthan (GoR, undated a). Deficient monsoon is one cause of drought, and this exacerbates groundwater overexploitation and insufficient freshwater availability. The impacts of drought can be loss of crop and livelihood, amongst others. With greater warming in the 2020s and 2050s, it is expected that the demand-supply gap of water would also increase. This would further increase the vulnerability of the city with a greater population in the 2050s.

Steps to manage drought situations are laid out in the Drought Management Manual of the State of Rajasthan and is addressed at the state level with implementation at the local level. Therefore, it is assumed that the preparedness will be high for the 2020s, while the management plans will need to be revisited for later years.

Water Logging and Floods

While the State of Rajasthan lies in a semi-arid region, there have been instances of floods in many areas during the monsoons. Floods in urban areas can occur during monsoons due to extreme storm events, faulty planning of drains, choking of drainage systems, and unplanned growth or settlements. In the Flood Management Manual for State of Rajasthan, Jaipur is classified as a flood prone area as it falls in the basin of river Banas, though it tends to drain well (GoR, undated b). However, in August 2012, Jaipur experienced a downpour of 170 millimeters of rainfall in a period of two hours.[13] The event was the highest such rainfall witnessed since 1981, and it caused flooding and water logging in several parts of the city.[14]

In the future, as the quantum as well as intensity of monsoonal rainfall is said to increase with changes in the climate and global warming, with it being more severe in the 2050s than in the 2020s. Therefore, the vulnerability of the city to water logging and flood events will be higher in the 2050s than in the 2020s.

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[13] See http://www.indianexpress.com/news/flood-in-rajasthan-jaipur-goes-under/995105

[14] See http://economictimes.indiatimes.com/heaviest-rainfall-in-31-years-floods-jaipur/articleshowpics/15613625.cms

Water Supply and Climate Change Conclusions

Jaipur city gets the majority of its water supply from the Bisalpur Dam. The dam was designed to provide 600 million liters of water per day. If the dam stores water at its designed capacity, Jaipur's water requirements will be met over the short term. However, at present the city is dependent on groundwater sources to meet more than one-third of its water requirements. In order to limit groundwater over-exploitation in the city, the authorities such as JDA and GWD have taken measures toward restricting groundwater use, building awareness about the city's limited water resources, and implementing rainwater harvesting for groundwater recharge. Also, it will be important to increase the recyclability of treated wastewater. The associated legal mechanism for these is discussed in the next section. However, assuring these measures—and new ones—are effective and achieve the intended goals, requires careful attention from the concerned authorities.

More accurate planning requires further study by climate scientists to downscale global circulation models with local-scale climate data using accepted methods. However, even without such studies, numerous “no regrets” strategies for water use optimization will improve the outlook for Jaipur and build climate resilience. The climate change scenarios reinforce the value of pursuing multiple efforts to improve water use efficiency to this end. Indeed, any changes in the quantity, timing, or intensity of rainfall are expected to exacerbate the challenges of meeting the competing water needs.

3. LEGAL AND POLICY FRAMEWORK RELATED TO WATER USE EFFICIENCY

As stated earlier, water regulation is a “State” subject as defined in the Indian Constitution. However, there is notable national level leadership support for increased water use efficiency. The Government of India's Approach Paper for the 12th Five Year Plan recognizes this need, as does GoI's climate change initiative. Under India's National Action Plan on Climate Change (NAPCC), the National Water Mission (NWM) is one of the eight national-level strategy documents to address water management under a changing climate scenario. The NWM recommends identifying water efficiency improvement as one of the principal measures to improve resilience to the adverse impacts of climate change and has the stated goal of increasing water use efficiency by 20 percent. In addition, the Ministry of Water Resources has announced its intention to launch the National Bureau for Water Use Efficiency. The proposed methods to improve water use efficiency under the NWM are as follows:

- Label water efficient products (similar to the energy efficiency certification provided by the Bureau of Energy Efficiency).
- Minimum standards for water use for commercial buildings (similar to the Energy Conservation Building Code (ECBC) which sets minimum energy performance standards for commercial buildings). Use of water efficient fixtures can be made mandatory in all new construction and remodeling involving replacement of plumbing fixtures in government buildings and commercial complexes.
- Highlight the impacts of savings through using water efficient products so that the general public becomes conscious about adopting these products.
- In the presence of proper water tariffs, water savings can be directly linked with cost savings and thus could be an incentive to adopt water efficient fixtures.
- Provide incentives to save water using labeled products.
- Enact laws which would make it mandatory for the consumers to adopt water saving devices and also ensure strict monitoring for quality parameters.
- Assess the market potential of water saving measures product and the possibility of public private partnerships.
- Funds may be ring fenced (protecting the transfer of assets) for developing water saving measures and assisting potential stakeholders and investors.

For its part, each state government is under an obligation to provide water of a certain quantity and quality to the public. However, the state government can exercise its discretion and devolve this responsibility to urban local bodies. On the one hand, the Rajasthan government has faced criticism for its failure to provide adequate water supply for various uses. On the other hand, water is scarce, and there is a plethora of examples of wastage or misuse of water, or a failure to put the available water resources to their most optimal use (e.g. use of potable water for gardening, flushing etc.). In this situation, it is important to manage water demand, as well as to improve the efficiency of water use. Unfortunately, the concept of water use efficiency has had little widespread traction until recently, as the growing incidence of water scarcity and resulting public pressure has forced the government, at various levels, to reconsider the significance of water use efficiency and the adoption of appropriate water efficient methods, practices, and technologies.

On the one hand, the Rajasthan government has faced criticism for its failure to provide adequate water supply for various uses. On the other hand, water is scarce, and there is a plethora of examples of wastage or misuse of water, or a failure to put the available water resources to their most optimal use...

The legal and policy analysis undertaken for this Guideline found that measures to improve water efficiency have been given a fair amount of consideration over the past decade, and continue to receive greater attention in light of the increasing acknowledgment of the water crisis facing the city of Jaipur. As a starting point, though, any effective legal framework requires (1) standards; (2) a management control tool such as licensing or permitting; (3) enforcement monitoring, complete with an established frequency as well as a reporting mechanism; and (4) meaningful sanctions, or consequences for non-compliance. This can be supplemented with well conceived incentives that encourage behavior change and provide the needed support to facilitate compliance and ensure the success of such policies.

In order to achieve the stated goals of improved water efficiency under the NWM, and related government water resource conservation objectives, this Guideline broadly recommends addressing two overarching issues. First, the reality is that existing measures in Rajasthan amount to a series of uncoordinated efforts. Many laws and policies have a similar focus, but in the absence of a coordinated regulatory and institutional framework—and implementation mechanisms that include effective enforcement—it is difficult for these to generate the desired results. For example, more than a decade after government buildings were supposed to implement rooftop rainwater harvesting in Jaipur, the most prominent of these buildings, the Secretariat Building, does not have a fully functioning system.

Second, more thoughtful efforts are required at the state and local levels to holistically and effectively encourage rainwater harvesting, water conservation, and wastewater reuse. Schemes introduced quickly in response to short-term water crises tend to be less effective since there is less time to plan properly, coordinate across stakeholders and responsible institutions, and analyze potential unintended consequences. This disconnects with the long-term vision for proper water stewardship for access across sectors. Taken piecemeal, these end up being treated as distinct problems addressed each in a different way rather than holistically. However, Rajasthan has been planning a step in the right direction—to adopt a water resources act (a framework water law) that would provide a broader framework to bring under one roof the various initiatives taken through different laws, regulations, and institutions.

Effective implementation will depend largely on political will, and the awareness efforts to educate the public and effectively engage them to adopt new approaches and technologies. Public awareness and education is a critically important part of removing misconceptions about Jaipur's water stress, and explaining the use and benefits of water efficient technologies. Done effectively, this can create demand, encourage manufacturers to respond with new fixtures, equipment, and technology, and even spur further innovations. If efficiency standards are made mandatory and enforced, manufacturers and retailers of more efficient fixtures and technologies can gain a competitive advantage in a market that is flooded with products from different manufacturers (many of whom operate on a small scale in the informal sector, with little consideration for environmental impacts).

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The incorporation of incentives (such as rebates in property tax/urban development charges, and taxes on fixtures and appliances, etc.), and disincentives (such as increases in water tariffs, banning fixtures and appliances below established standards, and withholding of completion certificate) in the regulatory framework can also provide the necessary demand impetus from domestic and commercial consumers, and supply impetus for manufacturers. However, a performance monitoring and regulatory mechanism is also required. For this, there is a proposal to establish, at the national level, a Bureau of Water Efficiency under the Ministry of Water Resources, along the lines of the Bureau of Energy Efficiency under the Ministry of Power. Indeed, for things like standards for fixtures and appliances, national regulations would be most effective, so as to avoid the problem of interstate transfer of inefficient goods.[15]

[15] See Section 5 for recommendations related to economic policy instruments including labeling schemes.

Rajasthan Legal and Policy Framework with Special Reference to Jaipur

The city of Jaipur is governed by state laws as well as local laws and regulations. Unlike other states, the entire function of water supply in all urban areas in the State of Rajasthan, including Jaipur, rests with the state Public Health Engineering Department rather than local bodies, such as the municipal corporation. The Jaipur Development Authority (JDA) is responsible for providing water connections to households in the city. The Jaipur Municipal Corporation (JMC) sanctions plans for new buildings in areas under JMC.

At the state level, there are actually many laws and policies in Rajasthan that strongly promote water conservation. They relate to rainwater harvesting, water and wastewater recycling and reuse, and water use efficiency. In many ways, the enabling policies to encourage proper water stewardship exist.

At the state level, there are actually many laws and policies in Rajasthan that strongly promote water conservation. They relate to rainwater harvesting, water and wastewater recycling and reuse, and water use efficiency. In many ways, the enabling policies to encourage proper water stewardship exist. They are just scattered across numerous policies and accountable institutions, which makes effective implementation a challenge. Some of the key laws and policies currently in place, or proposed, follow below.

Water Conservation

The State Water Policy (SWP) 2010 has numerous provisions promoting water use efficiency. Among other elements it states:

- Awareness and practical use of water saving technologies will be vigorously pursued.
- Public awareness will be improved, and technical assistance will be provided in order to encourage water use efficiency improvements in all sectors.
- Irrigation should be done through drip or sprinkler systems, as part of the effort to optimize groundwater use. (To its credit, the state government banned flood irrigation systems for gardens and parks maintained by the city and local corporations since May 2010, requiring sprinklers).
- All municipal water utility authorities will have programs to prevent leakage and unauthorized withdrawal, including assuring that all meters operate properly.
- All water rates will be set so as to convey the scarcity value of water and to generally motivate economy in water usage.

In addition, for the industrial sector, the SWP proposes water recycling facilities and the use of treated urban sewage water for cooling and other processes. It also proposes a water audit program for all industries. Similarly, the Rajasthan State Environmental Policy (RSEP) 2010 supports mandatory water audits of water utilities and industries (as does the Rajasthan State Action Plan on Climate Change—SAPCC, 2011). The RSEP includes measures to minimize water wastage, including the introduction of appropriate incentives for water neutral[16] or water positive technologies, promotion of water efficient fixtures in buildings through campaigns and trainings, and encouraging public-private partnerships for labeling and marketing of water-efficient products.

Furthermore, the RSEP includes the assessment of unaccounted for water (also called non-revenue water, NRW), and mandatory water metering for water-intensive industries as mechanism to assure conservation (RSEP, *supra* note 13). The SAPCC reinforces this, advancing water use efficiency through proposed actions including measuring NRW, and implementing plans to reduce losses, and rationalizing water pricing through increasing block tariffs (SAPCC, *supra* note 14). It also highlights the need to build awareness among all stakeholders on regular monitoring and maintenance of rainwater harvesting (RWH) structures, existing water conservation measures, building codes, bylaws for water conservation and water saving techniques, as well as training. A proposed Rajasthan Water Resources Regulatory Authority is also to promote water use efficiency and minimization of water wastage (section 11.m).

...the Rajasthan Industrial and Investment Promotion Policy (2010) acknowledges the benefits of dual-flush toilets, water efficient showerheads, graywater reuse for irrigation, dual plumbing systems to separate wastewater from graywater to facilitate reuse, among other approaches.

Beyond these state level water, environment, and climate policies, even the Rajasthan Industrial and Investment Promotion Policy (2010) acknowledges the benefits of dual-flush toilets, water efficient showerheads, graywater reuse for irrigation, dual plumbing systems to separate wastewater from graywater to facilitate reuse, among other approaches.

At the municipal level for Jaipur, there is no overarching law or policy framework mandating water efficient technologies or devices, or other conservation initiatives beyond one on public parks. The Master Development Plan 2025 envisages provision of drip irrigation systems for large and medium parks, in order to improve efficiency (JDA MDP, *supra* note 25). JDA has decided to reduce the lawn area of parks and to plant more trees instead to reduce

[16] "Water neutral" means that one reduces the water footprint of an activity as much as reasonably possible and offsets the negative externalities of the remaining water footprint.
(Hoekstra, 2008, p. 5)

water use. As noted in Section 5 of this report, there is also ample scope to expand wastewater recycling for urban garden irrigation.

Rainwater Harvesting

Specifically with regard to rainwater harvesting (RHW), the State Government of Rajasthan has made it compulsory for all new and existing buildings and government offices on plots over 300 m^2 to install RWH systems. Per the Rajasthan Urban Improvement (Amendment) Act, 2010 any building without RWH is deemed to be an "unauthorized development." A completion certificate, which is a pre-requisite to occupy the building and receive a municipal water connection from the PHED, can only be issued by the municipal authority once the appropriate RWH system has been installed in the building and is operational. The contravention of any provision of this section is punishable with imprisonment which may extend to seven days and/or with fine between Rs. 25,000 and Rs. 1 lakh. The Rajasthan Municipalities (Amendment) Act, 2010 includes an identical provision. The State Government's Urban Housing Department actually requires a RWH in areas less than 300 m^2.

Specifically with regard to rainwater harvesting, the State Government of Rajasthan has made it compulsory for all new and existing buildings and government offices on plots over 300 m^2 to install RWH systems.

To promote RWH, the Rajasthan government has introduced a system of incentives and has drafted proposals for disincentives. For example, the State Government grants relaxation in the urban development fee to private builders who have a roof rainwater harvesting system installed in the residential complex. The RSEP proposes policy and regulatory measures that include encouraging public-private partnerships, and emphasizes the importance of awareness building "among all stakeholders on regular monitoring and maintenance of RWH structures, existing water conservation measures, building codes and bylaws for water conservation; including training."

The State Government has also sought to make rainwater harvesting mandatory for industries. For example, in May 2010, the Rajasthan State Pollution Control Board (RSPCB) directed all the Group In-Charges and Regional Officers to impose a specific condition in consent to establish/operate orders being issued under the national Water Act and Air Act for construction of rainwater harvesting structures and rain gardens for rainwater harvesting in industries and projects having significant open areas, Rajasthan State Industrial Development and Investment Corporation (RIICO) areas, special economic zones (SEZs), large hotels, marriage gardens etc. (RSPCB, 2010).

At the city level of Jaipur, the Jaipur Development Authority (Amendment) Act, 2010 requires the installation of a RWH structure in every building constructed on a plot of land covering more than 300 m^2 in the Jaipur region. Other provisions duplicate the Rajasthan Municipalities Act, 2009. The Master Development Plan 2025 for the city of Jaipur also proposes rooftop rainwater harvesting as one of the measures to meet water demand in the coming years (JDA MDP, *supra* note 25). According to the Development Promotion/Control Regulations MDP-2025, rainwater harvesting shall form an integral part of the storm water drainage plan, at the time of sanction of any layout plan (JDA, 2011).

Flowing from the national level, one of the optional reforms under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) is "[R]evision of building bye-laws to make rain water harvesting mandatory in all buildings to come up in future and for adoption of water conservation measures." Unfortunately, while this requirement has been incorporated into regulations, in many cases it does not cover all the necessary parties (e.g. many regulations apply to buildings of a certain minimum area, new buildings only, etc.), and even otherwise, implementation has been poor despite the creation of a system of incentives and disincentives. A re-evaluation of the incentive structures and especially enforcement mechanisms is necessary in order to improve effective implementation.

Treatment, Recycling and Reuse of Wastewater/Graywater

The State Water Policy (2010) includes numerous provisions for treatment, recycling and reuse of wastewater. Among these, it seeks to:

- Promote water recycling and reuse
- Establish legal provisions in the bylaws of local bodies for water conservation and urban water recycling
- Promote wastewater reuse for appropriate uses based on treatment levels, including the creation of a knowledge bank to link treatment levels and water quality for reuse categories
- Provide incentives to industries and commercial enterprises to use recycled wastewater.

Impressively, according to the Notification for Integrated Township, the design of a township shall aim at water conservation, which would include recycling wastewater (GoR, 2007). The Rajasthan Township Policy and Policy for Residential, Group Housing and Other Schemes in the Private Sector state that the township/mini township scheme should have permission for a sewage treatment plant and it should be mandatory for the developer to establish and operate the same in the township. All water outlets and drainages should be networked to facilitate treated wastewater recycling for gardening, washing, flushing, etc. The urban local body is tasked with enforcement. Further, the developer should adopt a dual water supply system, wherever feasible (Township Policy, *supra* note 17). In fact, PHED has also proposed the formulation of a water recycling policy whereby new housing schemes with over 1,000 ft^2 area should have two separate water supply pipelines, one for drinking water, and the other for recycled treated graywater for non-drinking purposes. PHED proposes financial and other incentives to promote dual plumbing (JDA-MDP 2025).

Specific to the hotel sector, the best practices for environmental protection and conservation identified in the Draft Guidelines for Abatement of Pollution in the Hotel Industry include recycling/reuse of effluent after treatment within the premises and dual plumbing lines for graywater and black water (Draft Guidelines – Hotel Industry *supra* note 16). The Guidelines also do not allow hotels, restaurants and guest houses located amidst a water body to discharge even treated wastewater into the water body. The Guidelines encourage on-site wastewater reuse for irrigation or other uses.

Within Jaipur city itself, the Master Development Plan 2025 proposes the use of recycled water, establishment of small-scale sewage treatment plants at different sites in the city, and wastewater recycling from the existing sewage treatment plants...

Insofar as industries are concerned, the RIICO policy would encourage water recycling in all its existing and new industrial areas. It also indicates that the State would continue to support common effluent treatment plants in industrial areas, something also advocated by this Guideline.

Within Jaipur city itself, the Master Development Plan 2025 proposes the use of recycled water, establishment of small-scale sewage treatment plants at different sites in the city, and wastewater recycling from the existing sewage treatment plants at Dehlawas, Brahmpuri, Jaisinghpura khor and Relawata as some of the measures to meet the future water demand of the city (JDA MDP, *supra* note 25).

The JDA (Jaipur Region Building) Regulations, 2010 also provide for wastewater recycling (regulation 8.15). Plots measuring 5,000 m^2 or more are required to recycle gray wastewater from bathrooms and kitchens (this does not include sewage from toilets). The recycled graywater will be reused for gardening and flushing purposes, not drinking. Failure to recycle graywater will result in the imposition of a penalty of Rs. 100/- per m^2 of constructed area on the builder during the first year; thereafter the penalty amount will be doubled.

In addition, JMC and JDA have been pursuing recycling and reuse in a limited manner for garden irrigation purposes. For instance, in June 2009, JMC contemplated large-scale use of sewerage water for irrigating the almost 700 parks in the city. Already in the stage of a viability study, the civic body plans to invite interested parties wishing to install portable sewerage treatment plants across major locations in the city and sell the treated wastewater to JMC. In July 2010, JMC decided to sell treated wastewater from its sewage treatment plants to housing board colonies to water their parks and gardens. Similarly, JDA proposed to construct a one MLD treatment plant to treat sewer water in its large parks, and after that to use it for gardening. Work on the proposed treatment plant at Jawahar Circle has been completed and its water is being used for gardening (JDA RWH, *supra* note 41).

Importantly, JDA recognizes that the issue of wastewater reuse requires a greater emphasis on information, education, and communication (IEC) campaigns to educate citizens and government officials on mechanisms and benefits of recycling water to improve willingness to invest in such measures. The pace of enactment of new laws and amendments of existing laws to incorporate the requirement to recycle graywater has been slower than is the case for rooftop rainwater harvesting. Under JNNURM, enacting bylaws on recycled graywater reuse has been recommended as an 'optional' city-level reform, so while some of the cities covered by JNNURM have drafted such bylaws, few have already implemented them.

Already in the stage of a viability study, the civic body plans to invite interested parties wishing to install portable sewerage treatment plants across major locations in the city and sell the treated wastewater to JMC.

Legal and Policy Conclusions

In sum, the policy agenda advocating for water conservation, rainwater harvesting, and other water use efficiency measures is actually vast and spans many institutions. Even as they work toward similar objectives, the sheer complexity of laws and policies instituted and proposed through the Rajasthan Urban Improvement Act, State Environmental Policy, Municipalities Act, State Pollution Control Board, Urban Development and Housing Act, State Environmental Impact Assessment Authority, Rajasthan Industrial and Investment Promotion Policy, State Action Plan on Climate Change, JDA, etc., demonstrates strong state and local leadership, but a very complicated coordination environment for effective implementation. It at least partly explains why the impacts to date are not commensurate with the volume of legislation. The bottom line is that much of the legislation is well intentioned and properly directed, but more needs to be done to clarify institutional responsibilities, assure enforcement, and improve incentives and disincentives for effective and operational implementation. As already contemplated, a state level water resources act would serve well to consolidate existing policies to take a holistic view of the challenges in a coordinate fashion.

4. WATER USE SURVEY

Survey Methodology and Scope

WAISP conducted a survey of 14 different categories of water use in Jaipur during October 2012 to obtain an up-to-date assessment of trends in water use practices, and in order to identify opportunities to improve water use efficiency. Professor A. S. Jethoo and his colleagues have also studied water use practices in Jaipur in recent years (Jethoo, *et al.*, 2011a), surveying the residents in different socioeconomic sectors and documenting their use of water. Published results from that survey are consistent with results obtained from the water use survey conducted as part of the present project.

The survey instruments (questionnaires used by the survey team members during their in-person interviews with survey respondents) were designed separately for each category of water use. The residential sector was afforded the longest set of questions because of its large role in urban water demand and consumption. Other categories of water users were given shorter survey instruments, with varying types and numbers of questions in order to elicit the most relevant responses particular to those categories.

Most surveys, for example, asked questions about the source(s) of water supply, metering, number of people served, number and types of WCs, number of showers and faucets. Also, questions were asked about water using appliances such as washing machines, dishwashers, and desert coolers, including the type and frequency of use. Surveyors also asked about the size of gardens or landscaping (if any), and asked how irrigation was performed. They also asked about cleaning practices around the facility and for any vehicles, as well as water storage facilities available. The surveyors asked whether rainwater harvesting was practiced, or measures for water conservation or routine water audits. For the residential surveys, teams gauged the income level of households to try to ascertain differences in water use by low, middle and high income groups.

The residential sector was afforded the longest set of questions because of its large role in urban water demand and consumption. Other categories of water users were given shorter survey instruments, with varying types and numbers of questions...

An overall target sample size of 500 was planned and divided among the various water using categories (502 surveys were actually completed). Residential domestic users represented the largest number of respondents (302), while swim clubs, laundries, and crematoria represented the smallest number of samples. The sample size is deemed sufficient for most categories to enable data analysis and factual enumeration of responses, though responses may not be representative of the sectors for which only a few surveys were conducted. Due to time constraints, it was not possible to collect certain kinds of quantitative data, such as leakage rates or actual costs paid for water. These factors notwithstanding, information gleaned from the surveys provides insights and trends on current water use, and provides lessons and helps identify opportunities to improve water use optimization.

Table 8 provides a summary tabulation of the survey, with summary descriptive narratives of the survey data results following. These summaries inform the recommendations and opportunities presented in the next section this report.

Table 8: Summary of Selected Results from Jaipur City Survey of Water Use Patterns

Water use category	Number of surveys completed	Source of water, %			Water metered?		Average water consumption, L/d	Rainwater harvesting		Water filtered?	
		Mun-icipal	Tanker	Own source	% Yes	% No		% Yes	% No	% Yes	% No
Residential	302	89	0	11	85	15	NA*	5	95	64	36
Schools	60	56	3	41	NA	NA	NA	30	70	NA	NA
Healthcare Fac.	29	56	0	44	56	44	8,440	NA	NA	100	0
Religious Centers	32	88	3	9	79	21	425	NA	NA	NA	NA
Hotels	21	57	0	43	13	87	37,130	9	91	100	0
Service Stations	17	76	6	18	76	24	3,280	24	76	NA	NA
Government	10	90	0	10	NA	NA	NA	77	23	NA	NA
Restaurants	10	80	10	10	80	20	4,400	40	60	60	40
Gardens, Parks	6	50	0	50	50	50	NA	67	33	NA	NA
Transportation	5	80	0	20	100	0	22,400	20	80	40	60
Shopping Malls	4	50	0	50	100	0	32,750	75	25	100	0
Crematoria	2	100	0	0	50	50	1,250	NA	NA	NA	NA
Laundries	2	100	0	0	50	50	2,000	NA	NA	NA	NA
Swim Clubs	2	50	0	50	50	50	20,000	NA	NA	100	0
Total Sites Surveyed:	**502**										

***NA = Not Available; either the question was not asked, or the response was not provided.**

Survey Findings

Residential

The focus of the survey was on domestic water use, covering 302 households from residential clusters representing different areas of Jaipur. Nearly two-thirds of respondents were middle-income group (MIG) households, while about one-fifth were of the high-income group (HIG, 22%) and low-income group (LIG, 18%).[17] Most of the households depend entirely on municipal water supply (89%), although 12% of the middle income group and 16% of the high income group report having their own water sources. Of the households served by the municipal supply, 85% report that their connection is metered, and 96% of these meters function.

[17] Due to the complexity of verifying accurate household income, the survey team judged income level based on the appearance of the home and neighborhood and did not specifically request income data from respondents.

Photo: AIILSG

Pour Flush WC

- Very few respondents—just 9%—have have efficient, dual flush toilets. Pour flush toilets are used by close to 60% of the lower income group families. Single flush toilets are used by 73% of the middle income group, who on average had two WCs per household. The same single flush WCs are used by 45% of the high income group, who average four WCs per household. While 36% of the high income group report using dual flush toilets, only 1% of the middle income group has invested in the same. Overall, the use of dual flush systems was less than 10%.

- Surveyed LIG families generally have two faucets per household, while the figures for MIG households are six to eight, and for HIG eight to 12.

- Only 5% of households report having installed a rainwater harvesting system.

- About two-thirds of all residences surveyed filter their water before use, some using granular media and some reverse osmosis membrane filters. Reverse osmosis emerged as the predominant method for water treatment, used by 58% of the LIG, 68% of the MIG, and 72% of the HIG.

- Nearly three-fourths of the residences surveyed have washing machines, and out of the 220 homes with washers, nine out of ten were the older, less efficient top-loading models. Only 21 respondents reported owning a more efficient, front-loading machine. Modern front-loading washing machines provide the greatest water and detergent efficiency.

- Dishwashers, by contrast, are used by only 2% of the residences surveyed, where they are used an average of once per day.

- Two-thirds of the residences surveyed cultivate a home garden. Virtually all residents water their gardens by hand, either with a hand-held hose or with a bucket, which is much less efficient than drip irrigation or sprinkler systems.

- Residents surveyed reported having at least one car, three-wheeler, or other type of motor vehicle. About one-third of respondents wash their vehicle with water, while the remaining 65% wipe their vehicles clean with a cloth.

- Use of desert coolers, which consume large quantities of water, is prevalent by all three income categories. Over 85% of all families use these during summers. While these use far less energy than air conditioning, and do not require chemical coolants, they depend on water to function.

Schools

Half of the schools surveyed obtain water from the municipal supply, and most of the rest rely on their own wells, tapping groundwater. Two schools are supplied by tanker trucks.

- Two thirds (67%) of the schools surveyed had only pour flush toilets, while another 18% had single flush WC. None of the schools were equipped with efficient dual-flush toilets.
- Nearly half of the schools surveyed have some irrigated landscaping, and most of them use inefficient irrigation methods—hand-watering with a hose or bucket. Some schools in the suburbs reported using sprinklers.
- Only 3% of schools have invested in rain water harvesting, and one school is in the process of implementing RWH.
- Only one school is practicing water reuse, and none of the schools reported any efforts for awareness regarding water conservation.

Healthcare Facilities

Just over half of the healthcare facilities (55%) surveyed receive municipal water through metered connections. The remaining facilities receive water from unmetered private sources. They ranged in size from no beds to 1,563 beds, resulting in a wide range in water consumption.

- Some 59% have single flush WCs, while 31% have flush valves, and barely 3% have efficient dual flush systems. Though 10% did not respond to this question.
- Interestingly, 72% of the health centers have invested in water audits, while 18% have also invested in creating awareness on water issues.
- Healthcare facilities surveyed consume an average of 2,748 liters of water per day for dialysis, with one facility reporting a maximum use of 30,000 L/day.
- Most surveyed healthcare facilities perform some type of water treatment, through granular media filtration and reverse osmosis membrane treatment.
- Eighteen of the facilities indicated that they actively work to prevent water waste and 38% reported water reuse.
- Nearly one-third (31%) of the facilities irrigate their gardens with a hand-held hose.

Religious Centers

Most of the surveyed religious sites are connected to the municipal water system, while three are supplied from their own sources, and one receives water from tanker trucks. The majority of respondents reported that their water use is metered.

- Nearly two-thirds of surveyed houses of worship are equipped with manual pour-flush toilets. Six of the facilities surveyed are equipped with single flush toilets.

- Although not all of the religious sites have landscaping, on average the temples maintain about 6,500 ft^2 of landscaped area per site. Nearly one-third of the religious centers water inefficiently by hand (handheld hose), while three sites use buckets. One religious site irrigates with movable sprinklers, one has fixed sprinklers, and one uses drip irrigation, all of which represent more efficient irrigation methods.

- Respondents at religious sites indicated that the majority of staff and worshippers are unaware of water conservation needs. However, they also reported that, on an average, facilities are checked for water leaks four times per week.

Photo: Bahman Sheikh

Hand-held hose watering at 5-star hotel, with luxuriant waste runoff.

Hotels

Slightly more than half of the hotels surveyed (58%) are connected to the municipal water system, while the remaining hotels maintain their own water supplies. All municipally supplied hotels reported metering.

- The hotels averaged 20 WCs, or about one for every five guestrooms. Two-thirds of the hotels are equipped with dual flush toilets, while the remaining hotels are equipped with less efficient single flush models. Notably, this was the only category where dual flush systems were more prevalent than less efficient WC models.

- While all Jaipur hotels surveyed provide some sort of air conditioning, the majority use some form of air-cooled refrigeration. Only seven of the hotels surveyed use water-cooled systems.

- All hotels reported some form of water treatment; eighteen use some type of granular media, while two filter their water through reverse osmosis membranes. Others use alternate forms of water treatment.


Photo: Bahman Sheikh

Water-wasting “rainshower” in a 3-star hotel bathroom

- While not all Jaipur hotels surveyed have landscaping, on average the hotels have about 53,000 ft^2 of landscaped area. The largest hotel reported ten times that average. Nine hotels irrigate their landscaping with either fixed or movable sprinklers, while four facilities irrigate manually either with a handheld hose or a bucket.

- Fully 86% of hotels reported that they have invested in a water audit, and 62% also invested in creating awareness about water efficiency. Some 23% reuse water.

Service Stations

More than three-fourths of the surveyed service stations receive water through metered connections to the municipal water system. Three of the remaining service stations have their own water supply sources, and one service station receives water by tanker truck.

- More than 70% of the service stations offer manual car washes, while only 5 provide a mechanical car wash.

- Seven of the service stations re-circulate the wastewater from car washes.

- All service stations maintain between one and six WCs for employees and customers. Service stations average three toilets per site, with more than three-fourths equipped with single-flush toilets. One station has a pour flush WC, and the rest have dual flush toilets.

- All of the service stations have landscaping, with an average of 20,000 ft^2 of landscaped area per site. Over one-third of these sites are watered manually by a handheld hose.

- Rainwater harvesting is practiced at four of the 17 service stations.

Government Offices

Nine of the ten government offices surveyed are connected to the municipal water system, while the remaining building receives water from its own source.

- The largest government office building surveyed has 60 WCs, while the smallest office has only one. Seven of the offices are equipped with single flush toilets, while the remaining 30% of facilities have manual pour flush WCs. Notably, no government offices surveyed have efficient dual flush toilets.

- All government offices have landscaping, with the largest facility managing 120,000 ft^2 including 8,000 ft^2 of lawn. Landscape irrigation is almost entirely performed manually through inefficient handheld hose watering.

- Rainwater harvesting is practiced at seven of the ten facilities.

- One government office maintains a program to create public awareness about the need to conserve water.

Restaurants

Most of the restaurants (80%) surveyed receive municipal water through metered connections, though one has its own supply and one receives water by tanker truck.

- Only two of the restaurants surveyed use mechanical dishwashers. While the remaining eight restaurants wash dishes by hand, only three of them claim to wash utensils under constantly flowing water, and three report that they use water to thaw frozen food.

- Restaurants report between one and nine WCs per site, with an average of four toilets per restaurant. Three of the ten restaurants have single flush toilets, two have flush valve, and five restaurants are equipped with efficient dual flush toilets. The restaurants surveyed also reported an average of two urinals per site. Three restaurants use sensors in their bathrooms, and two use automatic water jets.

Hand-held hose watering at a Public Garden, with Ponding.

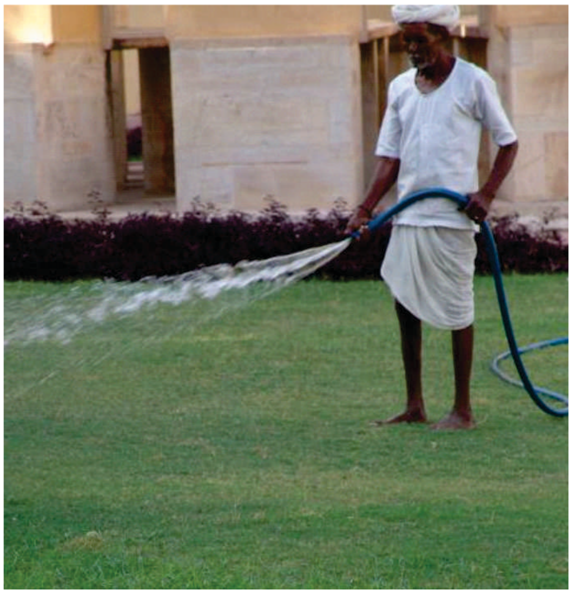

Photo: Bahman Sheikh

- Four of the ten restaurants practice rainwater harvesting, and four reuse their wastewater.

Gardens

Three of the six gardens surveyed are connected to the municipal water system, one of which is metered. The remaining three gardens are served by unmetered private water sources.

- All surveyed gardens maintain WCs at their facilities, the largest of which had 25 toilets. An average of 14 WCs per garden was reported. WCs at three of the gardens are pour flush; of the remaining sites, two are equipped with single flush toilets, and one garden has dual flush toilets.

- Landscaped area at the surveyed gardens ranges in size from as small as 3,200 ft^2 to nearly 20 acres, with an average of about 5 acres of landscaped area per site. On average, landscaped area in the gardens is comprised of grass (43%), with an equal amount of area dedicated to trees and shrubs (28 % each). Half of the gardens and parks are irrigated with movable sprinklers, while two of the gardens (29%) are watered by handheld hose. Of the remaining two sites, one is watered with drip irrigation, while the other is irrigated through a fixed sprinkler system.

Photo: Bahman Sheikh

Grossly leaking garden irrigation hose attached to firefighting water supply.

- Two-thirds of the gardens augment their water supply with rainwater; the average rainwater storage capacity is 5,000 L.

- While five reported having modern equipment and four reported taking steps to prevent water waste, only half of the sites claimed to have water conservation plans in place.

Transportation Hubs

Transportation hubs surveyed included a railway station, airport, and three bus stations. All five are dependent on a municipal water source through a metered connection.

- All transportation hubs provide toilets, with the largest having up to 40 WCs. On average, the transportation hubs maintain 15 WCs per site. Three of the five have single flush toilets (the railway and two bus stations), one is equipped with dual flush, and the remaining hub has pour flush WCs.

- One of the five hubs provides water for the coaches, and one hub uses water to clean the coach compartments.

- Two of the five use water to wash floors, while two other stations only mop, and one facility sweeps the transportation center.

- All surveyed transportation centers are located in landscaped areas, the largest of which is 5,000 ft^2, with an average of 2,750 ft^2. Two of the five landscaped areas are irrigated manually (one by bucket and one by handheld hose), and one hub is irrigated with a fixed sprinkler.

- Four out of five transportation hubs reported some type of water reduction measure, including filtration, water reuse, rainwater harvesting.

Photos: AIILSG

Leaking water supply pipe.

Shopping Malls

Half of the shopping malls surveyed are connected to the municipal water system, while the remaining two have their own water sources. All four respondents reported that their water use is metered.

- Shopping malls reported between 20 and 40 WCs per site, with an average of 27 toilets per shopping mall. Three of the four malls are equipped with single flush toilets while one mall had water-conserving dual flush toilets.

- Three of the four shopping malls have landscaping, and irrigate an average of 700 ft^2 of landscaped area per site by handheld hose.

- The majority of malls maintain their floors by sweeping four times per day. Only one reported washing floors with water twice daily.

- Three of the malls reported practicing rainwater harvesting and water recycling.

Other Categories

Of the remaining categories, the small survey samples suggested the following:

- The two crematoria surveyed use dual flushing WCs and perform cleaning by mopping. Their landscaping (between 500 ft^2 to 1,000 ft^2) is inefficiently irrigated by handheld hose.

- Of the two laundries surveyed, one is equipped with a modern front-loading washing machine. The other establishment washes laundry by hand. One of the two laundries reportedly reuses water and plans to conserve water in the future, but neither facility has a plan in place to reduce wastewater discharge.

- Of the two swim clubs surveyed, one has a municipal water supply while the other receives a private water supply. Both reuse wastewater from showers to irrigate landscaping, and one also redirects filter backwash for irrigation. This also helps to reduce overall wastewater.

5. OPPORTUNITIES AND RECOMMENDATIONS FOR WATER USE EFFICIENCY

Water Conservation Opportunities

Across developing countries worldwide, the cost-benefit of water conservation practices can rarely be calculated on the basis of the exceedingly low tariffs charged, which often do not recover operations and maintenance costs. Even so, it is generally less costly and more sustainable to pursue efficiency measures than solely invest in new supply infrastructure. Below we present numerous water conservation approaches and concepts based on the survey result outcomes, as well as global best practices.

Rainwater Harvesting

Rainwater harvesting is already widely practiced in Jaipur, and there is a rich historical record of this practice since ancient times as well. Among other sites, the Malaviya National Institute of Technology campus maintains several rainwater harvesting systems that recharge the harvested water into the groundwater aquifer. Indeed, the JDA requires rainwater harvesting systems in all developments over 300 m^2 in size, including government buildings, schools, malls, etc.

Our survey, however, indicated that, while a notable percentage of high and middle income families are dependent on municipal water supplies, they have not taken initiatives to harvest rainwater. Despite substantial efforts to promote RWH at the community level through *jal doots* (workmen trained to implement RWH under the guidance of JDA engineering staff), fewer than 5% of families surveyed have adopted the practice.

Still, because the monsoon rains are restricted to only some 20 days from July through September, this poses challenges. One option would be for the government

Photo: Bahman Sheikh

Scale model of a community level rainwater harvesting system

Photo: US Dept. of Agriculture

Rainwater harvesting storage tank

to provide a connection line to collect rainwater from colonies in order to directly recharge groundwater. Another alternative would be to invest in more surface rainwater storage capacity to carry the harvested rainwater over at least some of the long, dry part of each year. Either way, the city should establish design criteria for planning and constructing rainwater harvesting systems that maximize their benefit to the community with affordable costs and public health protection.

Some analysis by the government is warranted, as it could prove that district-wide water harvesting systems might be more cost-effective than home-based systems, under the short wet season conditions in Jaipur. A formal calculation of cost-effectiveness of rainwater harvesting systems is generally standard practice, examining a variety of conditions (catchment size, area served, demand for water, type of demand to be met, etc.). Unfortunately, however, the traditional cost-benefit comparisons are not adequate to the task because of the artificially low value price of water, and the sheer scarcity constraint.

Furthermore, our survey indicates that other more nuanced efforts are worth consideration to increase RWH. For instance, staff and worshippers at religious facilities demonstrated only a 10% to 12% awareness of water related issues. In fact, Hindu temple rituals include offering water to the gods in large numbers during the month of sawan, which is during the Monsoon. Demonstrating rainwater recharge at this time would create a better understanding of the issue and legitimize the practice more broadly.

Water Audits

While our survey showed that 86% of hotels and 72% of hospitals questioned have conducted a water audit, most other facilities do not follow this practice. Water audits are very useful to identify wastage and water losses in a home, government facility, company, industry, or other establishment. In a parallel effort supported by USAID/India, CII's Triveni Water Institute is conducting numerous water audits. A thorough water audit analyzes a facility's water use and identifies measures to optimize its use. Audits review domestic, sanitary, landscaping, and process water use. The audits can be a service performed free of charge by a water authority and can save the owners money by reducing water consumption and its associated costs when metered. It can also save the utility money by ultimately reducing demand, and thereby preventing the need to invest in expanding the supply infrastructure. Water audits can also be conducted by the facility owner, NGOs or private contractors, and can be combined with an energy or full environmental audit to optimize potential efficiency gains. One tool available is from the American Water Works Association, which offers free water audit software at: http://www.awwa.org/files/science/WaterLoss/WaterAudit.xls. Ultimately,

Source: Microsoft images

however, a water audit is only useful if the beneficiary implements key recommendations.

Water Metering

Authorities in Jaipur recognize the delicate balance of water supply to the city and metering is widely practiced. On the bulk water supply side, about one-third of the system has bulk meters, and the city has a plan to cover the full supply system by April 2014. At the end user lever, over 90% of high and middle-income residential households have meters. Where the survey found no metering, it was often in cases of non-municipal water supply. However, meter reading is infrequent and payment is not universally enforced. Service quality suffers and water losses increase without adequate investment enabled by consumption-based tariffs. This is important because utilities cannot effectively manage water resources and serve their customers without understanding user behavior. Universal metering of water accounts, frequent reading and billing, and assertive collection on the accounts is essential to city-wide water conservation and effective water management. Metering and billing are the most effective methods of sending the message of water conservation to all customer categories so that water is valued, as well as its service delivery. The most technologically advanced water metering now is automated and remotely read—“smart” meters with wireless telemetering equipment for centralized data collection. This type of metering bypasses manual readings, eliminates errors, and enables rapid feedback to customers about their water use behavior, enables early leak detection, and affords opportunities for water and cost savings. The Japanese International Cooperation Agency (JICA) is currently embarking on a pilot effort to reduce NRW in three areas of the city serving 3,000 households, which will provide valuable data for city authorities to eventually further reduce NRW through effective and accurate metering.

Metering and billing are the most effective method of sending the message of water conservation to all customer categories so that water is valued, as well as its service delivery.

Water Fixtures and Appliances

During site visits to the water fixture wholesale market in Jaipur, as well as meetings with builders and developers, it was apparent that awareness about water conserving fixtures and appliances is extremely weak. Such equipment is either not available or otherwise not easily factored into purchasing decisions, which are generally made against price and aesthetics alone. None of the fixtures sold on the market had a flow rate or discharge maximum rating, complicating consumers' ability to consider efficiency in their purchasing decisions. On one extreme, “rain shower” showerheads widely displayed and sold in the bathroom fixtures market and observed in hotel bathrooms are obviously highly wasteful of water. While viewed by the more affluent residents as a luxury, these showerheads place an

Photos: AIILSG

Wholesale market for fixtures.

Only in the high income bracket did the survey find over one-third (36%) of households using dual flush toilets. By contrast, only 1% of middle income families opted for this efficient type of toilet. Moreover, by far the most common washing machines were the less efficient top loading varieties.

unnecessary strain upon the community's limited water supply. The survey showed that the average low-income home has one WC and two to three faucets, while middle income homes have two WCs and six to eight faucets per household, and high income homes have up to four WCs and eight to 12 faucets. Only in the high income bracket did the survey find over one-third (36%) of households using dual flush toilets. By contrast, only 1% of middle income families opted for this efficient type of toilet. Moreover, by far the most common washing machines were the less efficient top loading varieties.

Therefore, the adoption and enforcement of standard-flow fixtures and appliances would be a highly effective method of enabling long-term efficient water use in homes, businesses, hotels, institutions, etc. The difficulty in widespread adoption and use of such technology is often due to (a) relatively higher initial investment cost, (b) lack of local familiarity and resistance to change, and (c) lack of maintenance budgets and skills. A list of standard flow-rated fixtures and appliances is provided in the *National Efficiency Standards and Specifications for Residential and Commercial Water-Using Fixtures and Appliances*, available from the California Urban Water Conservation Council (CUWCC) website at <http://www.cuwcc.org/WorkArea/showcontent.aspx?id=13966>. A few of the standards for fixtures and appliances from that source are shown in Table 9 below.

One option for the Jaipur government is to take a leadership role and retrofit government facilities with efficient technologies, such as waterless urinals, low-flow faucet aerators, recycled water for garden irrigation, etc., and provide brochures, tours, and water savings metrics that lead by example to demonstrate and publicize these approaches. Apparently, the Indian Plumbing Association is working with the American Plumbing Association to establish guidelines for flow rates in fixtures, and this initiative should be encouraged to improve water use optimization.

Table 9: Water Conserving Standards for Fixtures and Appliances

Fixtures / Appliances	Standard (English)	SI System
Residential or Commercial Toilets	1.6 gpf	6 Lpf
Residential or Commercial Faucets	2.2 gpm at 60 psi	8 Lpm at 4 bar
Residential or Commercial Showerheads	2.5 gpm at 80 psi	9.5 Lpm at 5.5 bar
Residential Dishwasher Water Factor (WF)	$\leq$ 6.5 gal/cycle/ft^3	$\leq$ 1.0 L/cycle/Kg
Residential or Commercial Clotheswasher WF	$\leq$ 9.5 gal/cycle/ft^3	$\leq$ 1.3 L/cycle/Kg
Commercial Urinals	1.0 gpf	4 Lpf
Pre-Rinse Spray Valve	$\leq$ 1.6 gpm	$\leq$ 6 Lpm

Public Outreach

Public awareness regarding the need to conserve water is the first step in gaining the public's cooperation to save water for the entire community. Behavioral characteristics of the population with regard to water use can have a huge impact on water use efficiency. An outreach program is needed to inform the public about the scarcity of water, its value as a vital resource, and the power of the individual citizen to have a significant impact on its conservation. Already, such programs are being initiated by the Jaipur Development Authority and the Public Health Engineering Department. Use of specialized professional firms with proven experience in public outreach programs would be essential to the success of ultimate public awareness of the need for efficient water use.

Modern Irrigation Methods

Based on our survey findings, hand held hose irrigation is currently quite common in Jaipur. Unfortunately, it is also inefficient, non-uniform, and results in water wastage. Some areas are over-watered, flooded, and result in runoff, while other areas remain under-irrigated. The best available technology today is drip irrigation, with many international and local suppliers and designers for small and large applications. Landscape irrigation with drip systems would save considerable volumes of water over hand watering and sprinkler systems, and is rarely used today in Jaipur. While our survey found sprinklers to be common to urban gardens, two of the six gardens surveyed irrigate with a hand held hose. Worse, half of residential households surveyed irrigate with a hand held hose.

Permeable Pavement

As Jaipur continues to urbanize and even prepares to build a metro transport system, it will further cover surfaces with impermeable features, particularly for transportation related infrastructure, such as asphalt parking areas, sidewalks, and streets. In cities around the world, this results in grossly reduced natural recharge of the groundwater during rainfall events. Instead, the rainfall causes flooding and forms pools of water that eventually evaporate into the atmosphere, or ends up as runoff into surface rivulets and drains away from the city. Since the city already performs rainwater harvesting from arterial roads, an appropriate complement in a city where groundwater is such an important source of water supply, a worthwhile water saving action to investigate would be use of appropriate permeable pavement materials and water absorbing/infiltration construction for new developments, and even gradual replacement of existing paved surfaces. Public parking surfaces and walkways in parks and other public places would be the first candidates for such conversion. It is also worth analyzing whether a municipal requirement for private properties to install permeable pavement would facilitate such investments by private builders and developers as well.

Behavioral characteristics of the population with regard to water use can have a huge impact on water use efficiency. An outreach program is needed to inform the public about the scarcity of water, its value as a vital resource, and the power of the individual citizen to have a significant impact on its conservation.

Water Reclamation and Reuse Opportunities

Centralized Wastewater Reclamation

Water recycling from a central treatment plant is now an established practice in many metropolitan regions of the world. Jaipur is no exception. As mentioned previously, new treatment plants are being designed and designated for effluent reuse in order to meet non-potable water demand—irrigation of parks and gardens, use in cooling towers and air conditioning units, and toilet flushing. As the population expands in the future, the amount of collected wastewater—or raw material for water recycling—will increase. With appropriate levels of treatment and disinfection, this will provide increasing opportunities for use of reclaimed water for many potable uses. In the long-term future, reuse of highly treated wastewater effluent, including reverse osmosis, for potable purposes will become inevitable. Potable reuse of treated sewage is already serving the capital city of Windhoek, Namibia, Singapore, and even Bangalore. Indirect potable reuse is practiced in the United States at Virginia's Occoquan Reservoir Augmentation, Texas' El Paso groundwater recharge, California's Orange County groundwater replenishment system, among others. One relatively small potable reuse case in India was observed in Pune City's Marigold Society, where highly treated wastewater (including reverse osmosis) is used to supplement drinking water during periods of extreme water scarcity as a way to avoid tanker truck water use with its inferior hygienic quality and higher cost.

Areas of Jaipur that are not currently connected to the piped sewage system would be candidates to establish decentralized water recycling systems... Opportunities for decentralized water recycling are abundant in Jaipur and should be studied in comparison with the centralized options.

Decentralized (Satellite) Water Recycling

Areas of Jaipur that are not currently connected to the piped sewage system would be candidates to establish decentralized water recycling systems. Each of these satellite plants would serve a cluster of homes, businesses, and institutional buildings with a collection system that would bring all wastewater to one location for treatment and disinfection—adequate for the intended use of the reclaimed water. Because of the proximity of the treatment system to points of use of the incoming wastewater, only a small distribution system will be needed to bring recycled water to the points of demand. Opportunities for decentralized water recycling are abundant in Jaipur and should be studied in comparison with the centralized options.

> *Printing and Dyeing Wastewater Treatment*

Sanganer is famous for its block prints, and there are some 300 to 400 small and medium-sized block printing and dyeing units. These provide employment opportunities to approximately 2,500 people who live around this area. The survey found that the majority of households in the vicinity are not connected to the municipal sewage network. The waste from the printing and dyeing units is discharged to natural water bodies and is used directly by farmers for irrigation without adequate water quality testing and controls. Establishing a combined effluent treatment plant and installing a sewage collection system would provide multiple benefits. A combined treatment plant by this sector will reduce the space requirements and waste treatment costs for the individual units. Furthermore, they are eligible to receive a combined subsidy from the state and national government to 50% of a treatment plant. Manufacturers could consider public-private solutions to the operation and maintenance of the plant, as most treatment facilities are run on a contract basis for municipalities.

Furthermore, a sewage collection system would improve sanitation and reduce health risks to this vulnerable population, and if reused for irrigation, would assure a safer water supply to farmers. Tirupur, in Tamil Nadu, has some good examples of treatment plants which have achieved zero discharge, as well as recovery of the brine solution essential for the dyeing process.

> Decentralized Sewage Treatment and Parks Irrigation

Sewage Treatment Plants for small complexes are becoming mandatory, and builders and architects must make these investments. Builders are now also considering running these treatment units on a long term contract basis, and would be open to robust and cost effective technology.

...JDA has established a wastewater treatment plant of 2 MLD capacity near Kartapura Nalla (open drain), and the treated wastewater is re-used to irrigate the landscaped areas.

In parallel to this, Jaipur has a large number of public parks or green areas in different residential sectors. Some of the better known green areas are: Ramniwas Garden, Central Park, Children Park, SMS Stadium, Jawahar Circle Garden, and Swarn Jayanti Park in Vidhyadhar Nagar. Notably, JDA is responsible for maintaining these public green areas, and Ramniwas Garden and Jawahar Circle Garden are already irrigated with treated wastewater from the STPs established on their premises. This has also resulted in closing five of the six tube wells in each of these gardens which were previously required for irrigation. This is an excellent example of how wastewater treatment and reuse can help to conserve groundwater resources. In addition, JDA has established a wastewater treatment plant of 2 MLD capacity near Kartapura Nalla (open drain), and the treated wastewater is re-used to irrigate the landscaped areas.

Plans are underway for the operation and maintenance of STPs currently under construction to be managed by the constructing firm for a period of five years. Besides the large-capacity plants (about 30 MLD capacity), there are a few small capacity STPs (about 1 MLD capacity) which are functioning in the city under JDA's jurisdiction. The treated water from these small treatment plants is mainly used for garden irrigation. As JDA plans to build more decentralized STPs in the

...for a homeowner or colony desiring to maintain a reasonable landscape without running out of potable water during dry periods of the year, the investment may well be worthwhile, irrespective of the results of a strict cost-benefit analysis.

city, the opportunity to continue to scale up the practice of wastewater reuse for garden irrigation can follow a similar model, including with contractors.

Graywater Reuse

Residential graywater reuse is gaining widespread acceptance in many arid and semi-arid regions of the world (Sheikh, 2010). Because graywater is untreated wastewater—albeit excluding WC wastewater—its use for irrigation outside the house must be undertaken only with the greatest care to prevent human exposure. Authorities should develop a guide similar to the Central Public Health Engineering and Environment Organization (CPHEEO) manual, focusing on waste water reuse and the appropriate parameters to enable agriculture, irrigation, construction activities, water for cooling towers, or flushing in water closets, as this would assist and encourage more graywater initiatives.

While graywater reuse saves water and money for the home owner, it also reduces the amount of wastewater flowing to the central treatment plant, thus reducing its treatment burden. In fact, JDA is pursuing the development of water reuse to irrigate parks through decentralized wastewater collection and treatment systems. Currently, three such systems are completed, and two more are under construction. Graywater reuse is less cost-effective than water recycling, even under conditions where water is more closely priced to reflect its value (Sheikh, 2010.) Nonetheless, for a homeowner or colony desiring to maintain a reasonable landscape without running out of potable water during dry periods of the year, the investment may well be worthwhile, irrespective of the results of a strict cost-benefit analysis. It would be advisable for Jaipur authorities to determine which water recycling option is the most important for the community, apply lessons from existing experiences, and to set policies with regard to graywater accordingly. Two specific opportunities observed through the surveys and site visits across Jaipur include:

> *Jaipur Railway*

Jaipur Railway has access to about 30 bore wells, plus municipal water supply which is used for its railways residential colony as well as to maintain railway platforms and coaches. While there are three railway stations – Jaipur Junction, Gandhinagar Station, and Durgapura Station – coach washing is done only at the main Jaipur Junction Station. An average of 230 liters of water is required to wash a coach, and about 190 coaches are washed daily. This consumes approximately 43,700 liters of water/day, and the effluent is discharged to common drains. Segregating this wash water for recycling would enable the bore wells to recharge. A suitable treatment unit could be installed to allow an estimated 80% of the water to be recycled. Since grease and dirt would be the major contaminants in the effluent, treatment costs should be lower than sewage treatment units.

> Rajasthan Road State Transport Corporation

There are six bus depots, namely Jaipur Depot, Vaishali Nagar Depot, Sanganer Depot, Deluxe Depot, Vidhya Nagar Depot 1, and Vidhya Nagar Depot 2. Data from three of these suggest that bus washing consumes an average of 100 liters per bus. They consume anywhere from 7,500 liters to 60,000 liters per day washing buses. Recycling facilities have been established at Vidhyanagar Depot and Jaipur Depot, and need to be extended to the remaining stations. Ensuring the use of functional mechanical wash equipment will also reduce water consumption.

Opportunities for Legal and Economic Instruments

While several legal and policy mechanisms are in place to encourage water conservation, policy makers should more thoughtfully consider specific instruments that will genuinely drive behavior change. This requires as much analysis regarding the type of mechanism as it does the level of incentive or penalty—otherwise customers maintain the status quo.

One major area of consideration for officials in Rajasthan (and indeed, nationally), relates to plumbing fixtures and appliances. As noted previously, even vendors of plumbing fixtures are not aware of the flow rates of the products they sell. These are purchased on the basis of aesthetics and price alone, since consumers have no information about their water efficiency. This offers many opportunities to improve water conservation:

- Labeling requirements for water fixtures and appliances can be the first step toward establishing standards for flow rates. This will begin to educate consumers and developers, and encourage vendors to stock these items. Rebates, taxes, and other economic instruments can be used to encourage or require efficient equipment, and discourage use of inefficient equipment and models, but these must be carefully designed in order to truly change behavior. Moreover, as lifestyles change and appliances like washing machines become more ubiquitous, promoting water efficient appliances is very important, particularly since they tend to be more expensive. Nearly three-fourths of survey respondents had a washing machine already, and 90% of these have a less efficient front loading machine. Conservation campaigns, cost-based water tariffs, and rebates or tax incentives will encourage more families to select more efficient appliances. By the same token, studies indicate that 40 liters of the 135 Lpcd (30%) are used just for flushing toilets. The WAISP survey found that only a very small fraction of people use dual flush systems. Making these mandatory and providing incentives for their use, or disincentives for single flush systems, would have an important water conservation impact.

- As noted previously, kitchen faucets generate graywater that can be reused within the household, for gardening, in toilets, or in desert coolers. Technical and/or financial support to families to establish graywater reuse systems would facilitate more widespread adoption. In addition, as Jaipur grows and tries to accommodate more dense new developments, the government could require such growth to include recycling and reuse initiatives in the design. For instance, new developments could be required to install dual piping to enable wastewater reuse in gardens, toilets, etc.

- Another important institutional measure would be to consider establishing a water demand management unit within the PHED or JDA. Such a unit could support municipal level conservation efforts through outreach campaigns, assist with enforcement, and engage users through technical assistance relating to fixtures, rainwater harvesting, graywater reuse, and other household or colony-level conservation initiatives.

While India lags behind other countries in introducing water efficient technologies and enacting laws making them mandatory, the country would not start from scratch. The Bureau of Indian Standards (BIS) is the premier agency in India assigned the task of developing standards, marking, quality certification, and quality control on a range of products and processes. A few BIS standards prescribe guidelines and certify sanitary products like cisterns, commodes, faucets, etc.[18] While BIS standards are not binding, they can serve as a starting point toward achieving such standards. The energy Standards and Labeling Program of the Ministry of Power, GoI, launched in 2006 provides a good lesson in this regard. It currently applies to 12 appliances, four of them mandatory since January 2012.

Moreover, voluntary standards such as from green rating certification programs like the Indian Green Building Council (IGBC) Green Homes, Leadership in Energy and Environmental Design (LEED) India, and Green Rating for Integrated Habitat Assessment (GRIHA), also provide important model approaches from which to consider minimum requirements. Many opportunities, then, exist to improve water conservation through legal and policy reforms.

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[18] *See*, for example, IS 774:2004 – standard for flushing cistern for water closets and urinals (non-plastic) cisterns; IS 2326:1987 – automatic flushing cisterns for urinals and IS 7231:1994 – specification for plastic flushing cisterns for water closets and urinals.

ANNEX 1: BEST PRACTICE CASE STUDIES

This section comprises a number of best practice case studies and reference materials for further review by water sector stakeholders. These cases represent examples from India and from around the world, and were selected on the basis of the relevance to the Indian context in the pursuit of urban water use efficiency.

Select Indian Case Studies

1. Pune Marigold Housing Society: Direct Potable Reuse

Location: Marigold Cooperative Housing Society is a residential housing complex of 100 high-end apartments in Kalyani Nagar, Pune city. The society occupies approximately one-fourth of a larger property of around 46 acres, including a large decorative lake that receives runoff from surrounding areas and wastewater effluent from the building's treatment system. The rest of the area is still being developed. The housing society's area includes 10,000 m^2 of lawns and gardens.

Photo: Bahman Sheikh

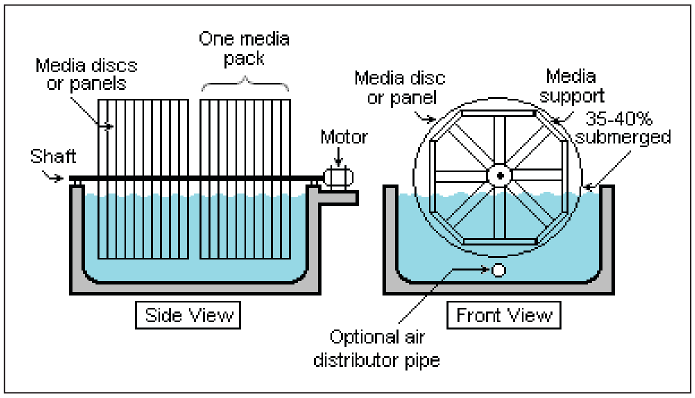
Aeration Tank

The Problem: For five years, residents of Marigold Cooperative Housing Society put up with the stink from a drain that flows along the property into a river and was a rich breeding ground for mosquitoes. The residents of Marigold Society also did not want to further pollute the river with the overflow from their septic tanks.

The Intervention: The Society decided to solve the problem by creating a bypass system for the drain first. Then they installed a system for secondary treatment for nearly 100,000 L/d of septic tank effluent using a patented "Nature-cell" rotating biological contactor (RBC) with a three hour residence time. The RBC process involves allowing the wastewater to come in contact with a biological medium in order to remove pollutants in the wastewater before discharge of the treated wastewater to the environment.

The RBC (Figure 5) consists of a large diameter steel or corrugated plastic media centered around a horizontal shaft placed in a concrete tank. The media is slowly rotated (1.5 rpm) and at any given time during the rotation about 40% of media surface area is in the waste water. Organisms in the waste water attach and multiply on the rotating media until they form a thin layer of biomass. This shaggy fixed film growth presents a very large very active population for the biological degradation of organic pollutants. During rotation, the media carries the biomass and a film of waste water into the air where oxygen is absorbed. The dissolved

Figure 5: Schematic Diagram of a Typical Rotating Biological Contractor (Reproduced from Wikipedia)



oxygen and organic materials in the waste water diffuse into the biomass and are metabolized. The radial and concentric passages in the media allow unrestricted entry of the waste water and air throughout the unit's total surface area for continued growth of the biomass.

Excess biomass shears off at a steady rate as the media rotates these solids and are carried through the RBC system for subsequent removal in a conventional clarifier. The RBC process does not require recycling, and unlike the activated sludge, can withstand shock loadings or variance in volumes. This process requires only 25% of the energy cost of the activated sludge process and the quality of the sludge enables it to settle even in shallow secondary clarifiers.

Water released after secondary treatment

Improvements in the System: While the original intention of the residents was to prevent pollution of the river body, repeated water cuts during summers forced the residents to buy water from the commercial water tankers. The water quality of the tanker water did not meet potable standards, and mixing this water with the Municipal supply was not the solution. The residents then decided to treat their secondary treated water to the tertiary stage by membrane filtration. They opted for the 100 picometer (Polymecide Membrane) membrane which has a pore size 150 times smaller than the smallest E. coli. New Water Singapore uses a 15 pico membrane which has a pore size only 100 times smaller than the smallest E. coli. The reverse osmosis unit can treat 3000 liters per hour and the treated water then passes through an ultraviolet (UV) unit and is chlorinated prior to storage. The Society has carried out repeated testing of the treated water which meets potable standards and is currently seeking permission from Pune Municipal Corporation to use it for potable purposes.

Photos: Bahman Sheikh

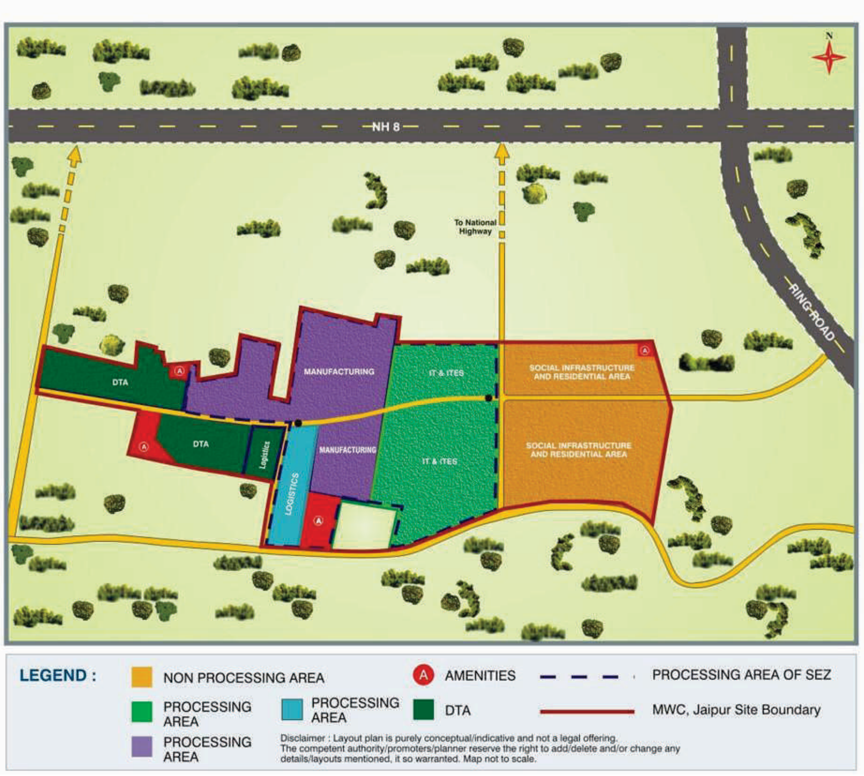
Membrane filters for tertiary treatment

This type of water recycling uses the most advanced practice and best technology available world-wide—emulating similar technologies currently in use in Singapore, Australia, and the United States (Orange County Groundwater Replenishment System in California, Occoquan reservoir augmentation in Virginia, City of El Paso, Texas, and others). It is anticipated that in the future, more critical water shortages will make adoption of this type of water recycling on a large scale a viable option.

2. Mahindra World City (Special Economic Zone), Jaipur

Location: Mahindra World City (MWC), Jaipur is the largest public-private partnership project in Rajasthan, and is expected to create large scale industrial development and employment[19] in the state. It is a 74% / 26% joint venture between Mahindra group firm *Mahindra Lifespaces* and Rajasthan Industrial and Investment Corporation (RIICO). The total project area is 3,000 acres, which is demarcated as Special Economic Zone (SEZ) under the SEZ Act of Government of India (2005). The multi-product SEZ will have three zones: IT (750 acres), light engineering, including auto and auto component (250 acres), handicraft (250 acres), besides zones for apparel, gems and jewelry, logistics and warehousing. A domestic tariff area for ancillaries to support export units and 714 acres of residential and social infrastructure has also been earmarked. At the time of report, approximately one-third (1,000 acres) have been developed and 41 industries have invested in the project. The project is located approximately 20 kilometers away from the centre of Jaipur city.

Mahindra Group's Eco-friendly Philosophy: The Mahindra group has a stated policy of adopting ecologically sound principles of sustainable growth. A group publication titled “Sustainability Review” (2011) states their commitment to contribute to the national goal of combating climate change by aligning their operations with the National Action Plan on Climate Change (NAPCC). Mahindra Group has also made it a point to embed green features in all new building projects. It has retrofitted its office in Mumbai (Mahindra Towers) to ensure that it is energy-efficient. Mahindra World City (MWC) has developed an in-house team of engineers and architects as certified energy saving analysts. The Management Development Centre of the Mahindra Group at Nasik, Maharashtra has adopted rainwater harvesting



Layout of Mahindra World city.
Source: MWC publication

[19] Twenty companies have signed up for these zones, who will invest more than Rs 1,000 crore, employ 75,000 people and generate exports of Rs 35 billion within four years.

Photo: Dipak Roy

Sprinklers in the nursery

technology and converted all existing urinals into "waterless urinals" using bio-blocks. Water audits are carried out in all its Divisions.

As a part of its sustainability road map it sets very clear targets for reducing resource consumption. The target for 2012 was reduction of energy use by 2% against which the various Divisions had achieved 7.8% reduction as per the above energy audit report. The group reports special projects which have adopted the 3R (Reduce / Reuse / Recycle) methodology for reduction in specific water consumption and packaging waste. The MWC is one such project.

Water Use Practices in MWC: The SEZ project, when fully operational, will meet two-thirds of its water needs by using recycled water for all non-drinking usage. It will recycle its water as well as take treated sewage water from Jaipur and use it after tertiary treatment. The project has committed to adopt the following practices during the construction phase as per the communication from State Level Environment Impact Assessment Authority, Rajasthan:[20]

Construction Phase:

- Storm water control and its reuse as per CGWB and BIS standards for various applications
- Water demand during construction reduced by the use of pre-mixed concrete, curing agents and other best practices
- Separation of grey and black water done by the use of dual plumping line for separation of grey and black water.
- Treatment of 100% grey water by decentralized treatment
- Fixtures for showers , toilet flushing and drinking shall be of low flow either by use of aerators or pressure reducing devices or sensor-based controls

Operation Phase:

- Rain water harvesting for roof run-off and surface run-off to be complied as per GoI guidelines. Before recharging, surface run-off to be pre-treated to remove suspended matter, oil and grease.

[20] Letter dated 18 November 2010 from Rajasthan State EIA Authority on environmental clearance as per EIA Notification, 2006)

Work in Progress: As mentioned earlier, only one-third of the project area has been developed thus far. Therefore, this is very much work in progress. The Public Health Engineering Department (PHED) of Government of Rajasthan was to install the pipeline from the Sewerage Treatment Plant at Delawas (nearly 20 km away) for carrying treated sewerage water for reuse. However, the PHED has not been able to meet its commitment because no provision was made in its budget. In March 2011, it was finally decided that RIICO as a partner would provide the budget while PHED would lay the pipeline. The work is yet to be completed.

Reduction of potable water consumption is being considered by the MWC through the use of grey water from Central Sewage Treatment Plant for flushing and landscaping, low flow water faucets within the homes, rainwater/storm water management system and use of Xeriscape[21] in Landscape (so that the landscape will be drought tolerant and will consumes less water). Water saving is also done with the use of timer-based water sprinklers, drip irrigation system, moisture sensors, pressure regulating devices for water control and water meters etc.

Validation by Independent Agencies: The University of West Minister has conducted an International Eco-City Initiative: Global Eco City Survey in 2011, which includes the MWC in its profile (Joss, 2011). Because of all the efforts that it has made, Mahindra World City, Jaipur, has been identified as one of 16 projects globally, which are being supported by the Clinton Climate Initiative (CCI), a foundation for sustainable development promoted by former US President Bill Clinton.

3. Case Study in Lake Restoration with Private Participation: Man Sagar Lake, Jaipur, India

Introduction: Man Sagar Lake was created as an artificial lake in the 16th Century during the Moghul period, by Raja Man Singh of Amber. He erected a dam 700 meters long, 40 meters wide, and 15 meters high south-east of Amber. In 1727 Jaipur was established as a planned city on the periphery of Amber, and the southern fringe of the lake. Its ruler, Maharaja Sawai Pratap Singh, built a palace garden for entertainment in the middle of the lake during the 18th Century. It was called Jal Mahal, which literally means “Palace on water”. The lake would receive water from the adjoining hills as well as the city.

[21] A landscaping approach that incorporates water conservation techniques, such as low water consuming plants and vegetation, efficient irrigation methods, decorative hard surfaces, etc.

Photo: Down to Earth

Man Sagar Lake before intervention

The area of the lake has been estimated between 310[22] acres and 343[23] acres by different sources. The average depth of the lake was reported to range between 2.18 meters during peak monsoon to 1.62[24] meters during the dry season, before any interventions took place in the 1990s. Two main drains carry water from the drainage area which includes the adjoining Nahargarh hills as well as the city area: i) the Bramhapuri Nalla coming from the north-western flank of Jaipur city and entering into the southern region of the lake, and ii) the Nagtalai Nalla, coming from the eastern region of the city and entering into the south-eastern region of the lake. The catchment of the lake has been estimated to be around 23.5 sq km, of which approximately 40% is constituted of urban area, while the north-western hill slopes constitute the remaining area.

Challenge: As the city grew, water quality in the lake began to deteriorate. City authorities diverted most of the city's raw sewage to the lake in the 1960s, along with nearly half of the city's run-off. As a result, the lake became silt rich with a heavy organic load, which only grew with the city's population. Eventually, solid waste generated in the city was also dumped into the lake, and by the 1990s, there was very little water during the year except during the monsoon months. During the rest of the year, since the lake was mostly dry, it was used as an open defection ground, for grazing animals, and partly as a play ground by children.

The Bramhapuri Nalla releases about 30 MLD of sewage daily, which is now treated in a sewage treatment plant (STP) built by the Jaipur Municipal Corporation (JMC) in year 2007-2008. However, the capacity of this plant is 27 MLD, which means a part of the sewage flows untreated. The Nagtalai Nalla currently releases about 8 MLD into the lake, all of it untreated sewage.

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[22] This was reported in the Detailed Project Report prepared by PDCOR – an infrastructure project development company jointly promoted by Government of Rajasthan (GoR) and Infrastructure Leasing and Finance Services Limited (IL&FS) which was commissioned by the Tourism Department of GoR to prepare a tourism project on the site.

[23] Maximum spread during monsoon in report by Bharat Lal Seth in "Down to Earth," 15 September 2012.

[24] Central Pollution Control Board, 2003.

Restoration Approach: As far back as the 1980s, the Government of Rajasthan (GoR) had earmarked the land around the lake for tourism development in its Master Plan. During the late 1990s, the Tourism department of GoR engaged PDCOR Limited,[25] to prepare proposals for tourism development projects in Rajasthan. PDCOR developed one such proposal with a focus on the Man Sagar Lake. A number of plans were made to rejuvenate the lake until about 2000; however, these were unsuccessful due to a paucity of funds and the lack of incentives to undertake restorations (CSE). In 2002 the Ministry of Environment and Forests (MoEF) within the Government of India (GoI) prioritized the task of restoring the lake under the National Lake Conservation Plan. The MoEF identified the Jaipur Development Authority (JDA) as the nodal agency for the task and sanctioned a budget of Rs 247.2 Million for the project. The GoI share was Rs 173 million in this budget, while GoR was to contribute the remainder.

Photo: Down to Earth

Man Sagar Lake after rehabilitation

This commitment from GoI enabled decisive advances in the restoration effort. Among them, the Sewerage Treatment Plant serving the Bramhapuri Nalla was upgraded. (The Nagtalai Nalla sewage is diverted into artificial wetland treatment system). In addition, a two kilometer tourist trail was built as well as a one kilometer-long promenade. Even so, the budget provided under the National Lake Conservation Plan was insufficient to undertake a more comprehensive plan for developing the area and assure long-term operation and maintenance. Therefore, a tender was released in 2004 to engage private participation in response to which four consortia submitted bids.

The project was awarded to Jal Mahal Resorts Private Limited (JMRPL), led by Kothari Builders, giving them a 99 year lease agreement at an agreed annual lease amount of Rs 25.2 million, with a built-in provision for 10% increase every three years. “The objective behind private sector participation was to ensure funds to operate and maintain the pollution abatement infrastructure.” (Seth, 2012)

[25] PDCOR is a company jointly promoted by the GoR and private sector to facilitate infrastructure investments in Rajasthan.

Photo: Bahman Sheikh

Newly laid garden in the center of the restored monument

Results: The following summarizes the interventions undertaken to improve the quantity and quality of water in the lake and improve the habitat, and the corresponding results.

1. The lake bed has been dredged to a depth of 3 to 3.5 meters in 2008, as a result of which the water holding capacity of the lake has increased.

2. Both of the main drains into the lake (Bramhapuri and Nagtalai) have been by-passed by creating a new masonry drain of approx. 1.5 km, so that sewage cannot flow directly into the lake.

3. The STP run by the JMC with a capacity of 27 MLD which uses extended aeration technology has been upgraded. In addition, a Tertiary Treatment Plant (TTP) has been established by the JDA close to the STP, with a capacity of 7.8 MLD.

4. At three locations, JMRPL created 21 enclosures of constructed wetlands, covering an area of 40,000 m^2, providing further, natural treatment of the water coming out of the STP/TTP before discharging to the lake.

5. The storm water that enters the lake (estimated 7,050 million liters per annum) is estimated to carry about 200 tons of silt into the lake annually. The suspended load in the water entering the two *nallas* is calculated at 100 milligrams per liter and is constituted of both organic and inorganic material. JMPRL has created a sedimentation basin within the lake below the embankment where nearly 60% of this silt gets trapped, thus substantially reducing the silt load in the lake.

6. The improved water holding capacity of the lake, combined with the treated wastewater discharged, has turned the Man Sagar Lake into a perennial water body.

7. Selected aquatic vegetation has been introduced from the same region (Keoladeo National Park at Bharatpur) for beautification and to ensure that pollutants get absorbed.

8. As a result of the interventions, the water quality has reportedly improved substantially: In July 2005 and 2006 when the MoEF tested the water quality for biochemical oxygen demand (BOD), it was in the range of 115 to 210[26] milligrams per liter, well over the standard for quality of water for bathing. After interventions, the water quality has been recorded with a BOD of less than 30 mg/liter, the stipulated discharge norm as per the Central Pollution Control Board.

[26] Data on water quality improvement have been reproduced from "Down to Earth" CSE Webnet of 15 September 2012 (Author: Bharat Lal Seth).

In conclusion, the restoration of the Jal Mahal Project provides an example of a potentially effective public-private partnership for water reuse, improved wastewater treatment, as well as tourism development. Importantly, it provides a revenue model to ensure long-term maintenance. The lease itself, however, is under litigation within the Indian Supreme Court, where the scope of restoration vs. what could be defined as new construction is in dispute. Notwithstanding this situation, the model has proved effective in accomplishing the above noted results.

International Case Study References

1. Australian Water Savings Experience During an 11-Year Drought

During the years 1998-2010, Australia underwent a severe sustained period of drought, considered to be a harbinger of global climate change. Water supplies were so stressed that one state, New South Wales built a huge direct potable reuse system. All over the country, communities adopted water conservation measures in all water using sectors. Overall residential water use dropped from 315 Lpcd to 213 Lpcd over the nine-year period 2000 to 2009 (Cahill et al., 2011). This impressive (>30% percent) reduction in per capita water use was achieved with a nation-wide campaign of water conservation behavior change and institutional revisions in how water was managed. Three actions contributing to Australia's reduced water use are (1) adoption of outdoor water restrictions, (2) ultra-low flush WCs, and (3) water pricing policies. Another important factor in the conservation effort's success is tracking water use with accurate, quantitative data. This enables the communities to document and therefore manage water use according to goals and what the data indicates about progress toward those goals.

2. United States Department of Housing and Urban Development Water Conservation Benchmarking Tool

The United States Department of Housing and Urban Development (USHUD) developed a useful benchmarking tool for residential buildings to compare their water conservation efforts against established benchmarks as a means of monitoring progress and measuring success along the way to achieve their desired conservation goals. In order to develop the water consumption benchmarking tool, water consumption data was collected through voluntary release of information from thousands of buildings in nearly 350 public housing units nationwide. Regression analyses were performed on these datasets to see which of over 30 characteristics were most closely linked to water conservation. The benchmarking models were then developed by quantifying the effects of the building traits that most commonly correlated with water utilization. The benchmarking tool that resulted from this exercise is Excel-based and quite adaptable to various types of buildings for assessment of their water use characteristics and determination of best practices to reduce water demand. The Excel-based tool can be downloaded from: http://portal.hud.gov/hudportal/documents/huddoc?id=DOC_26031.xls

3. California Urban Water Conservation Council

California's climate and water supply characteristics are similar to Rajasthan's, although there are vast differences in demographic and other characteristics. Over the last 25 years, the California Urban Water Conservation Council (CUWCC) has worked closely with water authorities throughout the State of California for adoption of Best Management Practices (BMPs), each of which is designed for a specific action with an implementation path to reduce water demand. Over this period, residential water demand has dropped by ten percent—not as impressive as the Australian case, but significant with room for greater progress in the future. Much can be learned from this experience and the tools made available by CUWCC. Most of these experiences and technical resources are available on the website of the Council: http://www.cuwcc.org/

4. California Best Management Practices

In the early 1990s, a large number of retail water providers in the State of California in the United States signed agreements among themselves committing to water demand reductions using the most effective water conservation methods available. The list of these water conservation BMPs include:

1. Water survey programs for single-family residential and multi-family residential customers
2. Residential plumbing retrofit
3. System water audits, leak detection and repair
4. Metering with commodity rates for all new connections and retrofit of existing connections
5. Large landscape conservation programs and incentives
6. High-efficiency clothes washing machine financial incentive programs
7. Public information programs
8. School education programs
9. Conservation programs for commercial, industrial, and institutional (CII) accounts
10. Wholesale agency assistance programs
11. Retail conservation pricing
12. Conservation coordinator
13. Water waste prohibition
14. Residential ultra low flush toilet (ULFT) replacement programs

Over the last 21 years, these BMPs have been refined and have borne fruit so that water use levels have declined or remained unchanged in spite of significant population increases in the service areas of the BMP signatories. Detailed implementation and monitoring protocols for each of these 14 BMPs is available at the website of the California Urban Water Conservation Council: http://www.cuwcc.org/bmps.aspx?ekmensel=b86195de_24_0_7794_2

5. Water Saver Home

The CUWCC has developed a useful tool for the homeowner to inventory their own water use characteristics and compare them with best practices for water conservation and to make effective changes for water (and money) savings is the H2OUSE—Water Saver Home, accessed at: http://www.h2ouse.org/. An example, showing the benefit of a simple lawn sprinkler water use audit, from one of the many water savings tips in this website follows:

Photo: Bahman Sheikh

Automatic sprinkler system in use

An automatic sprinkler system is almost always the largest user of water. If you're looking for a way to save water it makes sense to focus on the big uses. It doesn't get any bigger than the sprinkler system.

From a horticultural standpoint, over-irrigation occurs much too often. However, it is most prevalent in the cooler fall months when summer irrigation schedules have not been revised to meet the current weather conditions. Over-irrigation causes three basic problems; it:

- pushes water beyond the root zone and is wasted. This occurs most notably in the case of turf grass.
- causes excessive run-off, which contributes to non-point source environmental pollution.
- generally degrades plant health.

There are a number of ways to reduce outdoor water use and automatic irrigation and all of these recommendations are explored in great detail in this web site.

Saving water outdoors depends on a number of factors including the type of plant material, the soil, landscaping practices, climate, irrigation system efficiency, etc. It can all be a bit overwhelming. Many water utilities offer free landscape audits. An audit is a great opportunity to meet with a local expert and discuss ways to improve efficiency on your specific landscape.

6. East Bay Municipal Water District's Watersmart Guidebook

East Bay Municipal Water District (EBMUD) is a retail water and sewerage provider for a large population on the eastern side of San Francisco Bay in California, USA. This water authority is one of the most aggressive in the United States in promoting water conservation. In 2008, EBMUD prepared and published a highly practical publication, entitled “Watersmart Guidebook”, with 242 pages of text, graphics, photos and charts providing its new business customers and their consultants with a wealth of up-to-date material for saving water. While the guidebook is primarily intended for new businesses seeking approvals within the EBMUD service area, the guidebook can assist other water agencies wanting to emulate similar approaches to water savings. The guidebook is freely available to anyone at: http://ebmud.com/for-customers/conservation-rebates-and-services/commercial/watersmart-guidebook.

Examples of Regulations Advancing Water Efficient Technologies and Labeling

The following section provides some international examples of regulations that promote the adoption and implementation of water efficient technologies, as well as recommended general best practice measures.

- **United States:** The Energy Policy Act of 1992 (Public Law 102-486) *inter alia* addresses water efficiency on a national scale and mandates the use of water-efficient fixtures. It is mandatory for new buildings to install domestic water efficient devices, and regulations define maximum water use standards for plumbing fixtures. In January 2008, Congress enacted new laws to limit the water use of dishwashers and washing machines.

  As part of the U.S. government's goal to lead the nation by example in improving energy and water efficiency, Executive Order 13123, Greening the Government through Efficient Energy Management (1999), directs government agencies to reduce their potable water consumption. This order calls on the government to implement all cost-effective water conservation measures in Federal facilities by 2010. The order also required Federal agencies to determine their baseline water use in fiscal year 2000, and report on their usage every two years. Agencies must also implement at least four of 10 cost-effective Best Management Practices (BMPs) for water conservation at up to 80 percent of their facilities by 2010.

- **Australia:** All Australian states have regulations relating to dual flush and low volume toilets for new houses and replacement products, and the same for aerators and flow regulators for showerheads and kitchen faucets. Suppliers are now under pressure to adopt a subsidized retrofit scheme for the installed base of old style single flush toilets, as is done in various states and cities in the United States.

- **United Kingdom:** Following amendments to Part G of Building Regulations, from 6 April 2010, all new homes will have to meet a water efficiency standard of 125 liters of water per person per day. The government has also introduced an Enhanced Capital Allowance (ECA) scheme for water efficient plants and machinery.

Labeling water efficient fixtures enables consumers to make informed choices on the water efficiency of a product when purchasing. It also helps to raise public awareness regarding water conservation and encourages more water efficient products on the market, and saves money over time when water is priced and billed properly. Several countries have well-established schemes to label water efficient fixtures and services.

- **United States:** WaterSense (http://www.epa.gov/watersense/) is a voluntary partnership program by the United States Environment Protection Agency (USEPA) with various companies, which was launched in June 2006, and is designed to encourage water efficiency in the country. WaterSense labeled products meet EPA's specifications for water efficiency and performance and are typically about 20 percent more water efficient compared to corresponding conventional products. WaterSense has many resources available, including the National Efficiency Standards and Specifications for Residential and Commercial Water-Using Fixtures and Appliances, available at: http://www.epa.gov/WaterSense/docs/matrix508.pdf

- **Australia:** The national government's Water Efficiency Labeling and Standards (WELS) Scheme is responsible for the WELS water efficiency star ratings on products. The Smart Approved WaterMark is another simple identification label, which is applied to water efficient outdoor products in order to assist consumers to make informed choices.

- **New Zealand:** The water efficiency labeling regulations are modeled on the Australian WELS scheme. However, unlike the Australian scheme, there is no government mandated registration scheme and no minimum performance requirements are imposed.

- **United Kingdom:** The Bathroom Manufacturers Association (BMA), a leading trade association for manufacturers of bathroom products, promotes Water Efficient Product Labeling.

- **Singapore:** In 2006, the Public Utilities Board (PUB), the national water agency, introduced the Water Efficiency Labeling Scheme (WELS), a voluntary program, which covers faucets, showerheads, dual flush low capacity flushing cisterns, urinals and urinal flush valves, as well as clothes washing machines. The scheme became mandatory for water fixtures in July 2009.

- **China:** There are no federal laws that set standards for plumbing equipment. However, large cities such as Beijing, Tianjin and Shanghai have taken measures to promote domestic water saving, including subsidizing water-saving faucets or toilets and establishing education programs.

- **Israel:** The Water Authority has announced further measures to reduce water consumption, including the distribution of 1.2 million household devices to reduce the flow of water from faucets. It plans to issue a tender for the purchase and distribution of the devices, which are currently mandatory only in new buildings.

Reference Examples of Water Reclamation and Reuse

Aertgeerts, R., & Angelakis, A. (Eds). (2003).
State of the Art Report: Health risks in aquifer recharge using reclaimed water.
Geneva, World Health Organization.
Retrieved from: http://whqlibdoc.who.int/hq/2003/who_sde_wsh_03.08.pdf

As competing demands place pressures on water supplies in India and elsewhere, a body of literature has developed around experiences and projects built to recharge depleted aquifers with treated municipal wastewater. The World Health Organization's *State of the Art Report: Health Risks in Aquifer Recharge Using Reclaimed Water* examines the many facets associated with safe groundwater recharge with reclaimed water. Importantly, these guidelines include regulatory considerations to safeguard public health, an examination of the range of treatment levels and options prior to aquifer recharge, methods to assess health risks, and public perceptions and outreach strategy considerations to assure public acceptability. Moreover, the document includes case histories, including an example of soil aquifer treatment in Morocco for aquifer recharge, as well as an example of advanced wastewater treatment prior to groundwater recharge in the United States.

Brown, C. (2000).
***Water conservation in the professional car wash industry.* United States, International Car Wash Association.**
Retrieved from: http://www.carwash.org/docs/default-document-library/water-conservation-in-the-professional-car-wash-industry-.pdf?sfvrsn=0

Following water use restrictions imposed in eastern United States during the summer of 1999, the International Car Wash Association commissioned a survey of conservation techniques used in the car wash industry and constituted a think tank of industry experts to examine the means for designing water efficiency standards and advance policy discussion on water conservation and reclamation in the industry. The report finds significant saving in water use in professional car washes where conversation equipment, including a reclaim system is used. The needs of the car wash operator—conserve water, reduce discharge, meet regulatory requirements, or some combination thereof—dictate the selection of the installed reclaim system. The report includes a list of steps developed by industry associations for use by professional car washes during droughts and water shortages. The report also discusses cost components for retrofitting existing car washes. Moreover, the document highlights two programs developed through industry and utility cooperation to promote water conservation, and with applicability in other locations: the Conservation Certification Program developed by the San Antonio Water System, Texas, together with the Southwest Carwash Association. And the Seattle Public Utilities, Washington, conservation grants to professional car wash operators to install reclaim systems at their facilities. These examples will be of interest to decision makers at municipalities and utilities. This document presents an example of how industry groups can get in front of policy discussions on water conservation and reclaim, to represent the interests of their constituents.

Bryck, J., Prasad, R., Lindley, T., Davis, S., Carpenter, G. (2008). ***National database of water reuse facilities summary report*. United States, WateReuse Foundation.**
Retrieved from: http://www.watereuse.org/files/s/docs/02-004-01.pdf

This project reports presents the design and management of a national database of reuse facilities, using a web-enabled application. Intended for use by water practitioners, the database was developed to advance the implementation and disseminate information on water reuse. The report details each step of the database design process: developing the survey instrument, designing and beta testing the web-enabled database, collecting state data on utilities, reaching out to state water utilities to complete the online survey to populate the database, producing reports, installing the final database application on a server for continual use. The report includes as annexures, a copy of the survey instrument, as well as, examples of two standard reports that the database produces: a summary of utility and reclaimed water facility, and a summary of reclaimed water use by end use category. This document is useful reference for national and state agencies that plan to develop relational databases for water utilities.

Department of Water Affairs. (2010).
***Strategy and Guideline Development for National Groundwater Planning Requirements. The Atlantis Water Resource Management Scheme: 30 Years of Artificial Groundwater Recharge*. P RSA 000/00/11609/10-Activity 17 (ARS.1). Republic of South Africa.**
Retrieved from: http://www.artificialrecharge.co.za/casestudies/Atlantis_final_10August2010_reduced%20dpi.pdf

This report produced by the Department of Water Affairs, Republic of South Africa, provides information about the Atlantis Water Resource Management scheme for the planned town of Atlantis (now a part of the metropolitan area of Cape Town), South Africa. The scheme, which evolved over a 30 year period, diverts treated domestic effluent and domestic storm water to two infiltration basins up-gradient of well fields to recharge the aquifer. From here it is abstracted and recycled for municipal use. The scheme diverts industrial effluent and industrial storm water to the coast down-gradient of the main aquifer to coastal recharge basins to raise the water table and prevent seawater intrusion. The report tracks the evolution of the scheme from its inception during the town planning stage in 1970, to the integrated scheme as it now exists. The report documents the efforts of engineers and scientists to design the integrated scheme, including technical and operational issues addressed over time. Finally the report draws lessons from the thirty years of operations, management and monitoring and makes recommendations for the need for integrated management to ensure the scheme's long-term sustainability. This report is useful reference for engineering and scientists to understand technical, operational and management challenges associated with the development and operations of an integrated water resources management system.

Economic Analysis Task Force for Water Recycling in California. (2011). Guidelines *for Preparing Economic Analysis for Water Recycling Projects.* California, State Water Resources Control Board.
Retrieved from:
http://www.swrcb.ca.gov/water_issues/programs/grants_loans/water_recycling/docs/econ_tskfrce/eagd.pdf

This document produced by the California State Water Resources Control Board provides guidance on conducting economic and financial analysis of water recycling projects. The guidance considers water recycling as a part of integrated resources management and recommends that planners, utilities and local governments begin by establishing baseline forecasts of land use, population, institutional, legal and other requirements; and establish clear water supply objectives and alternatives prior to the analysis. Economic analysis considers and quantifies societal cost and benefits of a project over a selected time horizon. Risk and sensitivity analysis form part of the economic analysis and quantify the effect of uncertainties in parameters and events. A financial analysis emphasizes the financial viability of a project and its ability to generate sufficient revenues to cover construction and operations costs. Such costs may be allocated across purposes and beneficiaries. The analysis is useful for designing capital financing mechanisms, estimating debt service requirements for a portfolio of funding sources, and identifying need for additional leverage. This document is a useful template for utilities and cities on how to work through an economic and financial analysis for a water recycling facility. Such analysis may be used for applying for grants and loans, as well as for evaluating alternatives for recycling projects.

Environment and Natural Resources Committee. (2009).
***Inquiry into Melbourne's Future Water Supply.* Australia, Parliament of Victoria, Paper No. 174 Session 2006-2009.**
Retrieved from: http://www.watereuse.org/files/images/Inquiry_into_Melbourne_s_Future_Water_0609.pdf

The Victorian Parliamentary Environment and Natural Resources Committee, constituted under the Parliamentary Committees Act 2003, as amended, produced this parliamentary report on the merits of supplementing Melbourne's water supply. Amongst other findings, the report recommends: mandating simple low cost water efficient fixtures; establishing an environmental sustainability assessment and rating system that includes water use efficiency and conservation; revising planning provisions and building regulations to promote storm water harvesting; and, setting and enforcing new recycling and reuse targets for treated wastewater. The committee also recommends that a groundwater management strategy be developed. This parliamentary report serves as an example for policy makers in India and other countries on undertaking a comprehensive assessment of a water supply system, vis-à-vis options to supplement water supply; and to deliberate and translate findings into actionable policy directives.

Environment Protection and Heritage Council (EPHC), Natural Resource Management Ministerial Council (NRMMC), & Australian Health Ministers' Conference (AHMC). (2006).
***Australian Guidelines For Water Recycling: Managing Health and Environmental Risks (Phase 1).* Retrieved from:**
http://www.scew.gov.au/archive/water/pubs/wq_agwr_gl__managing_health_environmental_risks_phase1_final_200611.pdf

Produced by the Environment Protection and Heritage Council, Natural Resource Management Ministerial Council, and Australian Health Ministers' Conference; these Australian guidelines on water recycling address—safe and sustainable—supply, use and regulation of recycled water schemes. These comprehensive national guidelines provide a consistent approach across Australian state and territory governments, and are intended to be implemented in collaboration with relevant health and environment authorities. The guidelines present a risk management framework that emphasizes management of recycled water schemes, as compared to simply using post-treatment testing. The framework recommends an analysis of health and environmental hazards, and critical control points, so as to undertake preventive measures that reduce risks to an acceptable low level. The elements of the risk management framework are grouped under the following categories: commitment to responsible use and management of recycled water; system analysis and management; supporting requirements (employee training, community, research and development, documentation and reporting); review (evaluation and audit). The document discusses risks from the use of water recycling from a sewage treatment plant and from graywater, and characterizes both maximum as well as residual risk. Preventive measures to reduce risk include treatment processes and reduced exposure, either by using at the site of use or restricting use. Monitoring establishes baselines, and is needed to validate systems and operations. Validation of system effectiveness is essential because of the potential health risks associated with recycled water. The risk management framework emphasizes consultations and communication, to ensure stakeholder support. The document includes case studies of recycling of treated water from sewage treatment plants for irrigation of commercial crop, golf courses, municipal landscaped areas; and, on the use of graywater in toilet flushing and outdoor uses. Policy makers in India and other countries will find the risk management framework presented in these guidelines as useful reference for developing similar approaches for water recycling schemes, to address health and environmental risks.

Federal Energy Management Program. (2011).
***Methodology for Use of Reclaimed Water at Federal Locations.* U.S. Department of Energy. Retrieved from:**
http://www1.eere.energy.gov/femp/pdfs/reclaimed_water_use.pdf

The U.S. Federal Government requires reduction of water consumption at Federal sites and under Executive Order 13514 directs Federal agencies to implement water reuse strategies consistent with state laws that reduce water consumption. This fact sheet, produced under the Federal Energy Management Program of the U.S. Department of Energy, provides information to Federal agencies on the process of initiating a water reuse project using reclaimed water. This fact sheet distills information from the 2004 EPA Guidelines for Water Reuse, to identify six key steps: (i) Understand state laws and contact state regulatory agencies. The use of reclaimed wastewater in the U.S. is regulated by state and local laws, and varies across states. (ii) Classify project type, to determine necessary water quality standards and treatment options; (iii) decide whether to purchase reclaimed water from local municipal wastewater treatment plant or produce reclaimed water on-site, based upon considerations such as conveying costs, population, reuse purpose and quantity required, etc.; (iv) secure permits; (v) work with an experienced contractor; and, (vi) communicate and educate people that will be exposed to the system. The fact sheet also includes two brief case studies of water reclamation projects at Federal facilities. This fact sheet would be a handy reference for staff at government facilities on the steps involved in starting a water reuse project.

Federal Energy Management Program. (2011).
NASA's Marshall Space Flight Center saves water with high efficiency toilet and urinal program: BMP 6 – toilets and urinals. **U.S. Department of Energy.**
Retrieved from:
http://www1.eere.energy.gov/femp/pdfs/nasa-msfc_watercs1_.pdf

This best management practice case study, produced under the Federal Energy Management Program of the U.S. Department of Energy, provides information about the success of a water efficiency program that included the development and installation of innovative high-efficiency toilet and urinal fixtures, at NASA's Marshall Space Flight Center (MSFC). High-efficiency fixtures are fixtures that exceed the current standards for toilets and urinals as set under the Energy Policy Act of 1992. The facility engineering team examined performance and operating standards of high-efficiency fixtures, together with the operational constraints related to replacement at the aged building, to develop tailored design specifications suited to the facility's old fragile plumbing. The team then tested these innovative high-efficiency fixtures at a demonstration project and measured results. MSFC is now retrofitting these high-efficiency fixtures at identified buildings across the flight center. The MSFC water efficiency program comprises: water metering, leak detection and repair, water management of cooling towers, water reuse for limited irrigation, native landscaping, and staff outreach. This case study demonstrates the successful use of innovative high-efficiency fixtures for replacement at a Federal facility with aging infrastructure.

Federal Energy Management Program. (2009).
Huntington Veterans Affairs Medical Center: BMP 7 - faucets and showerheads. **U.S. Department of Energy.**
Retrieved from:
http://www1.eere.energy.gov/femp/pdfs/huntingtonva_watercs.pdf

This best management practice case study, produced under the Federal Energy Management Program of the U.S. Department of Energy, provides information about the performance and economics of a water efficiency program that retrofit 178 faucets and 33 showerheads at the Huntington Veterans Affairs (VA) Medical Center in 2007. The medical center used in-house staff to replace the old faucets and showerheads with newer, water efficient models, which incorporated antimicrobial technology. These improvements save the medical center more than 1.5 million gallons of water each year. In addition the medical center also converted 87 toilets with water efficient, dual flush toilets. This case is an example of the water savings that can be achieved through the use of new, improved fixtures in buildings.

Federal Energy Management Program. (2009).
***Water reclamation and reuse at Fort Carson: BMP 14 – alternate water sources.* U.S. Department of Energy.**
Retrieved from: http://www1.eere.energy.gov/femp/pdfs/water_fortcarson.pdf

This best management practice case study, produced under the Federal Energy Management Program of the U.S. Department of Energy, provides information about the performance, economics and success of a water conservation program comprising water reclamation and reuse at the U.S. Army's Fort Carson. For over three decades, the base has used treated effluent from its wastewater treatment plant, to irrigate 180 acres of their golf course. Effluent is also reused as process water required in the operations of the wastewater treatment plant. In addition, over the past two decades, the base has successfully operated a vehicle wash facility that uses recycled water through a closed loop system. Through this water conservation program, the base saves approximately 303 million gallons of water annually. This case study demonstrates the potential for municipalities in India and elsewhere for water and cost savings through water reclamation and reuse.

Golf Course Superintendents Association of America (GCSAA) and The Environmental Institute for Golf (EIFG). (2009).
***Golf Course Environmental Profile, Volume II, Water Use and Conservation Practices in U.S. Golf Courses.* GCSAA.**
Retrieved from:
http://www.gcsaa.org/_common/templates/course/environment/EnvironmentLandingPageLayout.aspx?id=3544

This report produced by the golf course industry in the U.S. presents findings from a survey of over 2500 golf courses in the U.S. on water use and conservation practices. This survey was intended to establish a baseline for comparison with future findings. While the survey identified no difference between private and public golf course in the use of recycled water, it found that a higher number of the larger courses with higher maintenance budgets, used recycled water for irrigation. This report is an example of the role industry groups can play in promoting water use and conservation at their facilities.

Koeller, J. & Brown, C. (2006).
Evaluation of potential best management practices: Vehicle Wash Systems.
California, California Urban Water Conservation Council.
Retrieved from the CUWCC website: http://www.cuwcc.org/products/pbmp-reports.aspx

This report published by the California Urban Water Conservation Council provides an evaluation of a range of water savings practices in vehicle wash systems within the State of California. The study starts by examining water savings opportunity in different vehicle wash systems: conveyor carwashes; in-bay carwashes; self-service carwashes; and truck, bus and fleet washes. This is followed by a technical discussion of water reclaim and conservation practices and processes, used by businesses during each step of the operation of the different vehicle wash systems. Of particular interest to decision makers at municipalities and utilities in India and elsewhere, will be the discussion of approaches, such as, carwash business certification by utilities, and the use of municipal ordinances and state regulations on vehicle wash businesses to achieve water efficiency, as currently deployed by cities and states in the United States.

National Research Council. (2012).
Water Reuse: Potential for Expanding the Nation's Water Supply through Reuse of Municipal Wastewater. **Washington, D.C.: The National Academies Press.**
Retrieved from: http://nas-sites.org/waterreuse/

This comprehensive study by The National Research Council assesses the potential for reclamation and reuse of municipal wastewater to expand and enhance water supply alternatives in the United States. The report reviews the suitability of water—quality and quality—of processed wastewater and considers a range of reuse applications, including drinking water, non-potable urban uses, irrigation, industrial process water, groundwater recharge and ecological enhancement. Moreover the report assesses the current state of technology in wastewater treatment and production of reclaimed water, and compares the performance, cost, energy use and environmental performance of a portfolio of treatment options and discusses risk exposure to microbial and chemical contaminants from drinking reclaimed water. In emphasizing the need for quality assurance, the study recognizes the significance of developing new monitoring and attenuation technologies. Using U.S. and international case studies, the report identifies technical, economic, institutional and social issues associated with the increased adoption of water reuse, and the available legislative tools to address the same. Finally the report considers current barriers to implementation and proposes areas for research to advance the safe, reliable and cost-effective reuse of municipal wastewater. This document is a timely and valuable guide for India and other countries, which will need to assess and address these issues with the increasing reuse of municipal wastewater.

New Mexico Office of the State Engineer. (1999).
A Water Conservation Guide for Commercial, Institutional and Industrial Users. **New Mexico. Retrieved from:**
http://www.ose.state.nm.us/water-info/conservation/pdf-manuals/cii-users-guide.pdf

This manual, produced by the New Mexico Office of the State Engineer, provides step-by-step guidance on how to design and establish a water conservation plan, including water conservation guidelines for specific uses: domestic, landscaping, cooling and heating, and industry. The manual recommends that a water conservation plan be part of an integrated approach, address technical and human elements, be based upon accurate data, and follow a logical sequence of events. The water audit must assess not just how much water is being used, but also how and by whom, and that water quality is matched to the reuse application. The plan must consider true cost of water and use life-cycle costing to evaluate water conservation options. This manual is a useful resource for water utility engineers and water systems operators at commercial, institutional and industrial facilities.

State of California. (2009).
Regulations related to recycled water updated from Titles 22 and 17 California Code of Regulations. **California, Department of Public Health.**
Retrieved from:
http://www.cdph.ca.gov/certlic/drinkingwater/Documents/Lawbook/RWregulations-01-2009.pdf

The California Department of Public Health produced this publication as an aid to its staff regarding Titles 17 and 22 published codes. Requirements under Title 17, Division 1, Chapter 5, address the protection of drinking water supplies from contamination. The regulation assigns responsibility to the water supplier to implement a cross-connection control program, and includes detailed criteria for approval, construction, location, type, testing and maintenance of backflow preventers. (A cross-connection is a connection between a potable water system and an unapproved water system). Requirements under Title 22, Division 4, Chapters 1, 2 and 3 requirements, focus upon environmental protection and present water recycling criteria. These criteria address only recycled water from sources that contain domestic waste and specify required levels of treatment by the intended use of the recycled water (irrigation, impoundments, cooling, other), as well as, specific conditions for the area of recycled water use. The criteria also address: design and operation requirements for dual plumbed recycled water systems; use of reclaimed water for groundwater recharge; and, design, reliability, and operations and maintenance requirements for water reclamation plants. These California codes address the concerns of public health and environmental protection pertaining to the use of recycled water and are a source of reference for policy makers and those responsible for designing standards and regulations in India and elsewhere.

U.S. Environmental Protection Agency (EPA). (2012).
Guidelines *for Water Reuse.* 600/R-12/618. Washington, D.C., United States. U.S. Environmental Protection Agency and U.S. Agency for International Development.
Retrieved from: http://www.waterreuseguidelines.org/

The Guidelines for Water Reuse debuted in 1980, and were updated in 1992 and 2004. This national guidance, produced as a collaborative effort between the EPA and USAID, updates and builds upon the *2004 Guidelines for Water Reuse* with the purpose of facilitating the further development of water reclamation and reuse practices. In the U.S. water reuse is regulated by states. This document inventories state water reuse regulations and discusses regional variations of water reuse practices in the U.S. Using illustrations from U.S. and international experiences, the document discusses: steps that should be considered for water reuse in the planning and management of an integrated water resources plan; types of reuse applications; advances in wastewater treatment technologies relevant to water reuse; funding decisions related to the development and operations of sustainable water system; and, best practices for involving communities in planning projects. The document discusses a portfolio of wastewater treatment options and recognizes that the cost of wastewater treatment can be balanced with the desired level of water quality for the purpose of reuse. Moreover, the document includes over a hundred U.S. and international case studies of water reuse for various applications, as well as an inventory of recent water reuse research projects and reports. Given the context of urbanization and associated population increases and land use changes and the dynamics of changes in local climate patterns, this document will serve as an authoritative reference for India and other countries on water reclamation and reuse practices.

World Health Organization (WHO). (2006).
***WHO guidelines for the safe use of wastewater, excreta and greywater, Volume 1: Policy and regulatory aspects* (3rd ed.). Geneva, World Health Organization.**
Retrieved from: http://whqlibdoc.who.int/publications/2006/9241546824_eng.pdf

This four-set volume of WHO guidelines is recognized by UN-Water—the coordinating body of UN agencies and programs working on water issues—as representing the position of the United Nations system on the issues of wastewater, excreta and graywater use and health. Volume 1 gives policy makers an overview of the benefits and risks of such use and provides guidance on the development of a conducive policy environment, regulations and institutional arrangements. The guidelines recommend that policy to addresses primary health concerns related to such use may be designed around the subject of food security or environmental protection. The widespread—formal and informal—use of wastewater, excreta and graywater in agriculture and aquaculture can contribute to nutrient and water recycling; however international policy implications on trade of safe food products and any implication of negative health impact need to be addressed.

These guidelines are based on a risk analysis approach similar to the methodology underlying the development of food safety standards that provide adequate health protection and facilitate trade in food. The guidelines recommend that the planning and development of projects include a health impact assessment or an environmental impact assessment with a health component. And that public health policy for interventions ensures the most cost effective measures or combination thereof. The guidance outlines a step-by-step process for policy formulation and adjustment and introduces the concept of intersectoral collaboration, including mechanisms to promote collaboration and integration at the national and local levels to achieve effective institutional arrangements across sectors. The guidance for developing regulations to ensure safe use identifies and discusses the following essential functions: identification of associated primary health hazards; generating evidence for health risks and the effectiveness of protection measures to manage them; establishing health-based targets to manage health risks, implementing health protection measures to achieve the targets; and monitoring and system assessments.

This document also includes a brief synthesis Volumes 2, 3 and 4 of this set, which focus upon technical information on health risk assessment, protection measures, and monitoring and evaluation. As water scarcity increasingly drives interest in the wastewater, excreta and graywater use in agriculture and aquaculture, this document offers useful guidance for policy makers on the design of policy, regulation and institutional arrangements.

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